water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Report Number: P WMA 04/B50/00/8310/15

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM

WP10197

Main Report with Executive Summaries of Reconciliation Strategies

Original

FINAL REPORT

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM

WP10197

Main Report with Executive Summaries of Reconciliation Strategies

Report no.: P WMA 04/B50/00/8310/15

Prepared by:

aurecon

Contact person:
WP Comrie
Aurecon Centre,
Lynnwood Bridge Office Park,
4 Daventry Street, Lynnwood Manor, 0081, South Africa

T: +27 12 427 3108
F: +27 86 764 3649
M: +27 82 808 0435
E: Werner.Comrie@aurecongroup.com

In association with

ILISO Consulting (Pty) Ltd

MBB Consulting Services (Nelspruit) (Pty) Ltd

WFA Aquatic Ecology (Pty) Ltd

Chuma Development Consultants CC

WFA Water Resources (Pty) Ltd

Submitted
December 2011

PROJECT NAME	**:**	**DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM (WP 10197)**
REPORT TITLE	**:**	Main Report with Executive Summaries of Reconciliation Strategies
AUTHORS	**:**	S.C. Vogel
REPORT STATUS	**:**	Final Report
REPORT NO.	**:**	P WMA 04/B50/00/8310/15
DATE	**:**	December 2011

Submitted by:

....	28/3/2012
W.P. COMRIE Water Unit Manager	(Date)
....	28 - 3 - 2012
J BEUMER Study Leader	(Date)

Approved for the Department of Water Affairs:

....	29-03-2012
T NDITWANI Chief Water Resource Planner: NWRP (North)	(Date)
....	29/3/2012
J.A. VAN ROOYEN Director NWRP	(Date)

LIST OF REPORTS

Glossary of Terms

Allocatable Water
Water available to allocate for consumptive use.

Acid Mine Drainage
Polluted and acidic water decanting from mines and reaching the resource supply system.

Development Options
A development option is a capital intensive intervention that will establish physical infrastructure which will have the ability to increase the water supply (e.g. a dam).

Environmental Water Requirement
The quantity, quality and seasonal patterns of water needed to maintain aquatic ecosystems within a particular ecological condition (management category), excluding operational and management considerations.

Eutrophic
Ecology lacking oxygen: used to describe a body of water whose oxygen content is depleted by organic nutrients (eutrophication).

Existing Lawful Use
An existing lawful water use means a water use which has taking place at any time during a period of two years immediately before the date of commencement of the Natural Water Act or which has been declared an existing lawful water use under Section 33 of the National Water Act.

Hypertrophic indicates a water body that is extremely eutrophic.

Integrated Water Resource Management (IWRM) Objectives
The objectives and priorities for water resource management, for a given time frame, which have been agreed by the parties as those which will best support the agreed socio economic development plans for the basin.

Internal Strategic Perspective
A DWA status quo report of the catchment outlining the current situation and how the catchment will be managed in the interim until a Catchment Management Strategy of a CMA is established.

Intervention Scenarios
An intervention scenario is a combination of reconciliation options which have to be implemented together over the planning period in order to achieve a water balance.

IWRM Plans
A set of agreed activities with expected outcomes, time frames, responsibilities and resource requirements that underpin the objectives of IWRM.

Level of Assurance
The probability that water will be supplied without any curtailments. The opposite of Level of Assurance is the risk of failure.

Management Options
A management option is maintenance, administrative or regulatory intervention that is implemented to improve the water use efficiency. Such intervention can either reduce the water requirements or increase the water supply.

Oligotrophic
Nutrient poor and oxygen rich, i.e. containing very little plant life and nutrients in its water, but rich in dissolved oxygen.

Reconciliation option
A reconciliation option can be a management option or a development option and is an intervention to either reduce the water requirements or increase the water supply.

Reserve
The Reserve is that portion of the natural flow that has to be available in a river or stream in order to sustain the aquatic ecology, and also to provide for basic human needs, in order to comply with Sections 16, 17 and 18 of the National Water Act (NWA), Act 36 of 1998. The Reserve is not a steady flow, but is a variable flow that mimics natural variations in flows in the river. The quantity that is required takes into account “normal” conditions, as well as drought conditions.

Resource Classification
A process of determining the management class of resources by achieving a balance between the Reserve needs and the beneficial use of the resources.

Validation and Verification
Validation is the process for verifying that the water use registrations on the Water Authorisation and Registration Management System (WARMS) were correctly done, and, Verification is the process for verifying that the water uses, registered in WARMS and in other data sources are lawful.

Diffuse irrigators
Irrigators who are not scheduled under any one of the Irrigation Boards or Water User Associations and who take their water directly from a river, i.e. from the run-of-river flows or from a farm dam in that particular river.

List of Abbreviations & Acronyms

AEC	Alternative Ecological Category
AMD	Acid Mine Drainage
ARC	Agricultural Research Council
BHN	Basic Human Needs
CEDI	Continuous Electron Deioniser
CMA	Catchment Management Agency
CMC	Catchment Management Committee
CME	Compliance Monitoring and Enforcement
DPLG	Department of Provincial and Local Government
DWA	Department of Water Affairs
DWAF	Former Department of Water Affairs and Forestry
E.Cond	Electrical Conductivity
EC	Ecological Category
ED/EDR	Electrodialysis and Electrodialysis Reversal
EIS	Ecological Importance and Sensitivity
EMF	Environmental Management Framework
EMP	Environmental Management Plan
ER	Ecological Reserve
EWR	Ecological Water Requirements (Ecological Component of the Reserve)
GDP	Gross Domestic Product
GIS	Geographical information System
GRDM	Groundwater Resource Determination Management
IAP	Invasive Alien Plants (vegetation)
IB	Irrigation Board
IDP	Integrated Development Plan
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
IWRMP	Integrated Water Resources Management Plan
KNP	Kruger National Park
LHWP	Lesotho Highlands Water Project
LHWP2	Lesotho Highlands Water Project – Phase 2
LNW	Lepelle Northern Water Board
MAR	Mean Annual Runoff
MED	Multiple Effect Distillation
MINWAC	Mining & Industry Water Action Committee
MSF	Multi-Stage Flash
NGDB	National Groundwater Data Base
NPV	Nett Present Value
NRF	National Research Foundation
NSDF	National Spatial Development Framework
NWA	National Water Act (Act 36 of 1998)
NWRS	National Water Resource Strategy
OWAAS	Olifants Water Assessment and Availability Study
OWAAS	Olifants Water Availability Study
PES	Present Ecological State
REC	Recommended Ecological Category

RO	Reverse Osmosis
ROD	Record of Decisions
RWQO	Resource Water Quality Objectives
SADC	Southern African Development Community
SALGA	South African Local Government Association
SANP	South African National Parks
SDF	Strategic Development Framework
SH	Stakeholder
SSC	Study Steering Committee
UF	Ultra-Filtration
UN	United Nations
URV	Unit Reference Value
V & V	Validation and Verification
VAC	Visual Absorption Capacity
VAPS	Vaal Augmentation Planning Study
VRESAP	Vaal River Eastern Sub-system Augmentation Project
WAAS	Water Availability Assessment Study
WC	Water Conservation
WC/WDM	Water Conservation / Water Demand Management
WCDM	Water Conservation /Demand Management
WDM	Water Demand Management
WFGDS	Water for Growth & Development Strategy
WfW	Working for Water
WMA	Water Management Area
WMP	Water Management Plan
WQMP	Water Quality Management Plan
WQT	Water Quality Time Series Model
WRC	Water Research Commission
WSDP	Water Services Development Plan
WUA	Water User Association
WWTW	Waste Water Treatment Works

Measurements

ℓ/uso	litres per unit sent out (electricity)
million m^3	million cubic metres
mg/ℓ	milligrams per litre
mS/m	milli-Siemens per metre (electrical conductivity)

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ANNEXURES

1. INTRODUCTION

The study area consists of the Olifants River Catchment and its immediate supply zone. Hence, the urban areas of Polokwane and Mokopane have been included in the study area. This study area is collectively referred to as “the catchment” in this report.

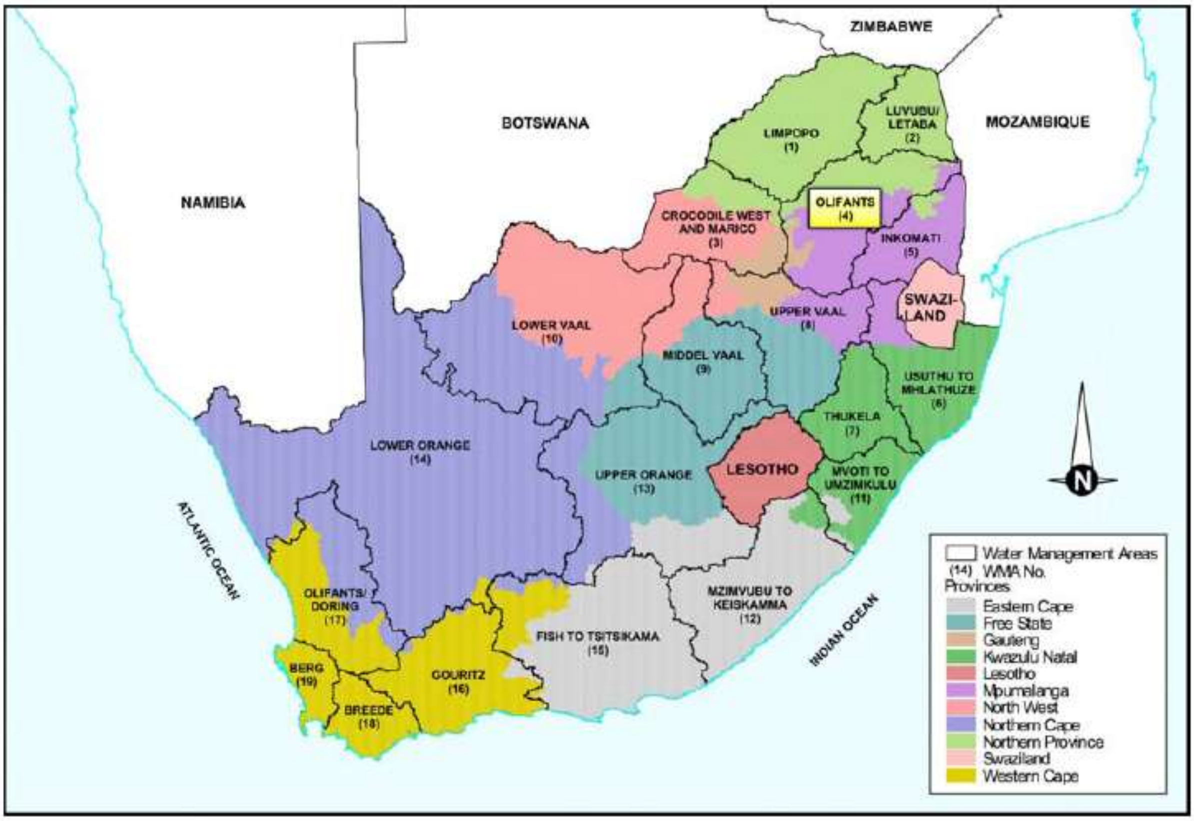


Figure 1.1: The Locality of the Olifants River Catchment

The Olifants River is fed by a number of tributaries of which the most significant on the left bank are the Wilge, Elands and Ga-Selati Rivers and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River flows directly from South Africa into Mozambique where it joins the Limpopo River. Developments in South Africa directly impact upon the water quality and quantity of the water flowing across the border into Moçambique.

The geology consists mainly of hard rock formations where Bushveld Igneous Complex is the most prominent occurring feature in the catchment. In the Upper Olifants Sub-catchment, in the vicinity of Emalahleni and Steve Tshwete Local Municipalities, lie extensive coal reserves. Along the Blyde River a large dolomitic intrusion extends along the river, curving westwards along the northern extremity of the catchment. Minerals such as copper in the Phalaborwa area, chrome and vanadium in the Steelpoort Valley occur in the lower portions of the catchment. Platinum reefs are found along the Dilokong Corridor (the Lebowakgomo to Burgersfort axis).

Economic activity in the Olifants catchment is diverse and ranges from mining, power generation, metallurgic industries and irrigation in the Upper sub-catchment, to irrigation, dry land, subsistence agriculture and ecotourism in the middle and lower sub-catchments. Approximately 5% of the Gross Domestic Product (GDP) of South Africa is generated within the Olifants catchment with the largest economic sectors inclusive of mining, manufacturing, power generation, government and agriculture. Coal is the dominant mineral mined in the catchment.

The Upper Olifants sub-catchment is predominately urbanised with the majority of the urban population concentrated in the Emalahleni (formerly Witbank) and Steve Tshwete areas. The land is extensively mined for its rich coal deposits which are exported through Richards Bay and also used locally in the coal-fired power stations. Much of the central and north western areas of the sub-catchment are largely undeveloped, with scattered rural settlements. The predominant land uses in the Middle Olifants sub-catchment include agriculture and extensive irrigation exploits. A number of platinum and chrome mines have also been developed in this area. Agriculture is the predominant land use, although vanadium and chrome mining also occur along the rural Steelpoort River. The Lower Olifants sub-catchment is rural in character, with the main urban centre being Phalaborwa. Eco-tourism is a prominent industry in the sub-catchment with a number of game parks and the Kruger National Park in the area. The main mining activities in this sub-catchment consist of copper and phosphorus excavations.

The Olifants River Catchment is currently one of South Africa's most stressed catchments as far as water quantity (due to high demand) and water quality is concerned.

1.1 PURPOSE OF THIS STUDY

The water requirements in the Olifants Water Management Area (WMA) and the adjacent areas of Polokwane and Mokopane, which are supplied from the Olifants, have increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

The Olifants River Catchment is currently perceived to be one of South Africa's most stressed catchments as far as water quantity and water quality is concerned.

A reconciliation strategy, aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future, is required for the basin and its water users.

Figure 1.2 shows the Olifants River Basin and the Study Area.

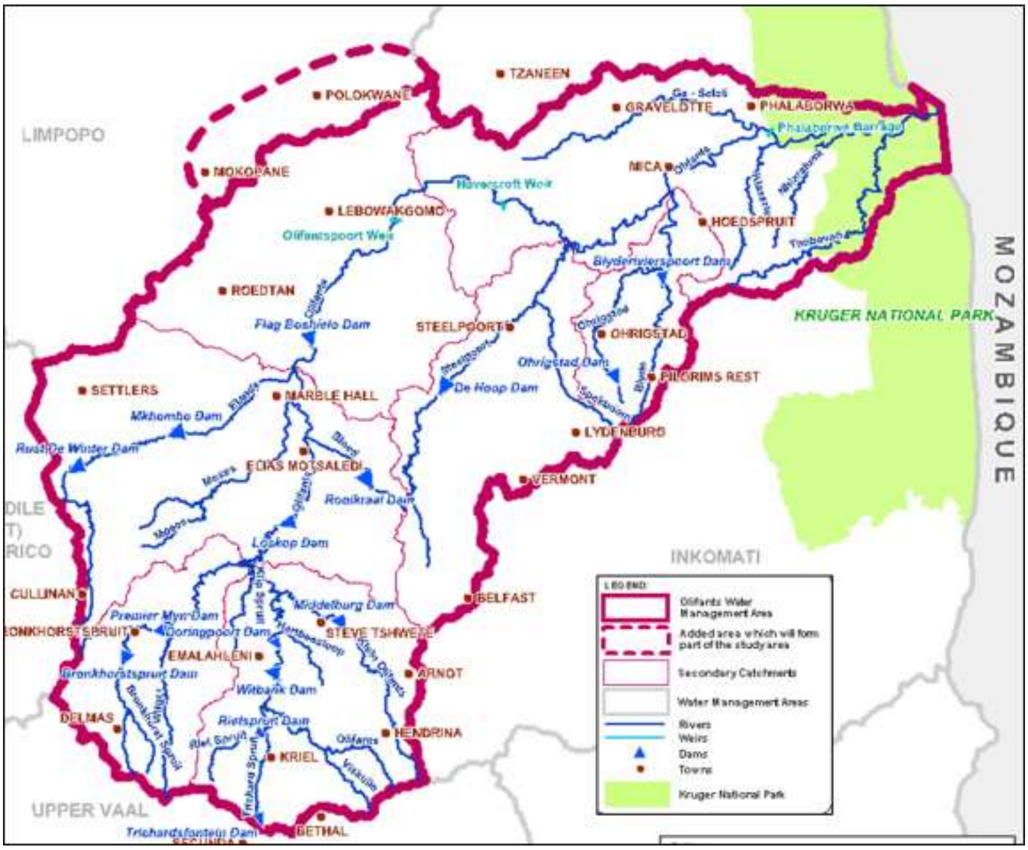


Figure 1.2: Olifants River Basin and Study Area

1.2 PURPOSE OF THIS REPORT

The study was executed and a number of task reports produced focussing on certain aspects. The list of the reports is included on page ii.

The key outcome of the study is the Reconciliation Strategy and that is dealt with in a separate document as well. This report however serves the purpose to provide a brief summary of the study findings and to serve as a general (quick) reference to the task reports.

1.3 REPORT STRUCTURE

The report provides a brief overview of the matters dealt with in all the reports finalises for the study. It provided a general introduction and present the information contained in the executive summary of the final Reconciliation Strategy in the body of the report in chapter 3. The report further also collates all the conclusions and recommendations from the other reports in Chapter 4. In Chapter 5 consolidated recommendations from all the reports are summarised and presented with the recommendations from the Strategy Report. The recommendations from the Strategy document are included in Chapter 5, paragraphs 5.1 and 5.2.

The full executive summaries of the other reports are included as annexures to this report for ease of reference.

2. OVERVIEW OF THE STUDY AREA AND STUDY PROCEDURE

2.1 SYSTEM DESCRIPTION

The study area consists of the Olifants River Catchment and its adjacent supply zones, i.e. the urban areas of Polokwane and Mokopane to the north west of the basin. The Olifants River catchment has several large dams located in the upper and middle reaches. The earlier dams were constructed to supply large irrigation schemes, while later dams were constructed to meet growing domestic, industrial and mining water requirements. All the dams are operated independently of each other. However water court orders require releases from Middelburg Dam, Witbank Dam and Loskop Dam but these orders do not seem to have been upheld in recent times.

While the majority of water users obtain their water from the major dams, there are also a large number of water users who obtain their water from farm dams, and run-of-river abstraction, referred to in this report as diffuse water use. There is also a significant supply to irrigators and mines from groundwater. The reconciliation strategies developed as part of this study do not address water shortages of these diffuse water users.

- In the upper part of the catchment, water use is mainly for power generation, mining and urban use, although run-of-river irrigation is also practised. In the upper parts of the Wilge River and Bronkhorstspruit there is significant abstraction for irrigation from groundwater (dolomite). In the middle part of the catchment most water is used for irrigation, while at the lower end of the catchment the Kruger National Park (KNP) requires that there is sufficient flow in the river to maintain the ecological integrity of the system. These conflicting requirements pose a significant challenge in the reconciliation process.

2.2 STUDY PROCEDURE

The study is anchored by technical and stakeholder engagement processes that are intertwined. **Figure 2.1** illustrates the interaction and relationship of the actions in the process.

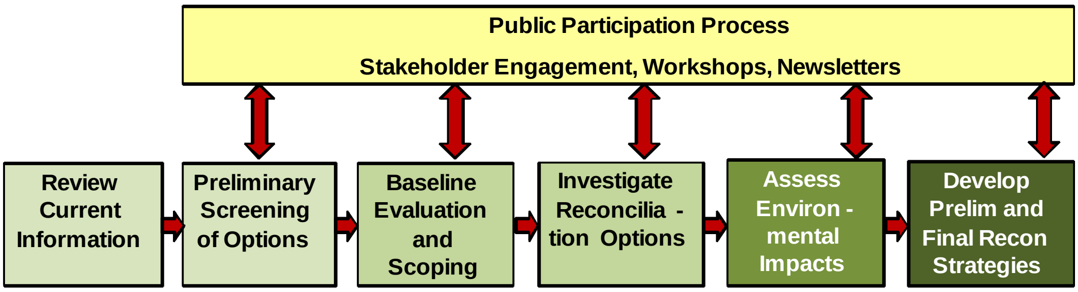
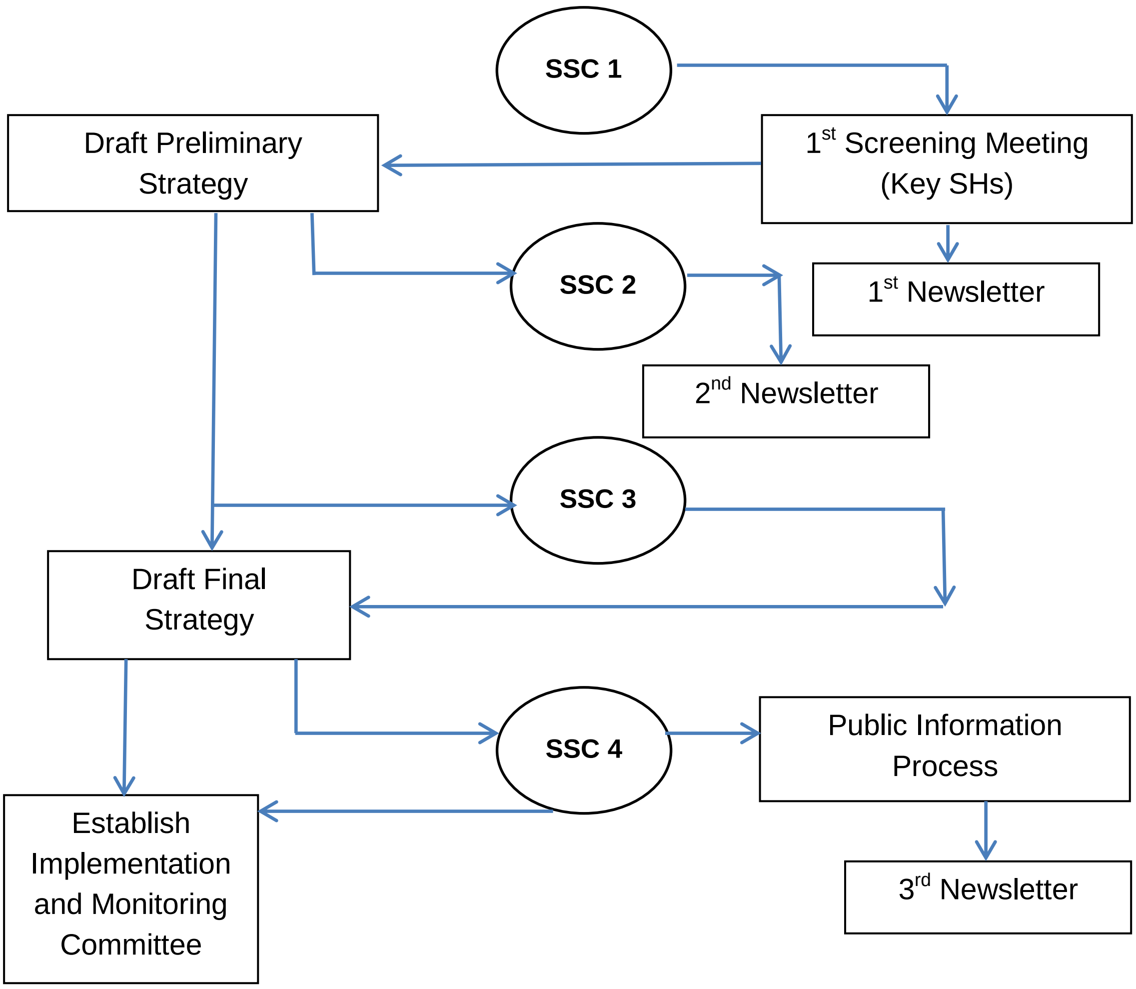


Figure 2.1: Technical and Public Participation Process

The technical process which is complete has followed the steps of **Figure 2.1**. The Review of Current Information concluded with the Summary Report (Report No P WMA 04/B50/00/8310/2) which summarised all relevant recent and current reports on the study area.
The Preliminary Screening of Options was performed at a preliminary screening workshop which was held on 7 July 2010 where a list of possible reconciliation options were evaluated by a group of key stakeholders who had to decide which options should be investigated further.

The further steps of the technical process, i.e. baseline evaluation and scoping, investigation of reconciliation options and assessment of environmental impacts all led to the development of the strategies – first a preliminary strategy which was developed halfway through the study to obtain an understanding of the reconciliation possibilities and to address the immediate needs and now this final strategy which has been developed with the improved information which has been obtained since the preliminary strategy.

To achieve the objectives of this study, all possible stakeholders were consulted through workshops and information sessions. The diagram in **Figure 2.2** depicts the process which was followed in the engagements.



Note: **SSC = Study Steering Committee**

Figure 2.2: Process for Stakeholder Engagement

3. RECONCILIATION STRATEGY SUMMARY

3.1 INTRODUCTION

The water requirements in the Olifants Water Management Area (WMA) and the adjacent areas of Polokwane and Mokopane, which are supplied from the Olifants, have increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

A reconciliation strategy, aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future, is required for the basin and its water users.

A preliminary reconciliation strategy was completed in November 2010. That preliminary strategy contains a water balance based on the best information available at that time.

The preliminary strategy identified a number of information gaps which had to be filled for this final strategy.

This final reconciliation strategy is an improved version of the preliminary reconciliation strategy, based on the improved information obtained.

Key elements of this reconciliation strategy are summarised below.

3.2 THE RESERVE

The Reserve is that portion of the natural flow that has to be available in a river or stream in order to sustain the aquatic ecology, and also to provide for basic human needs (BHN), in order to comply with Sections 16, 17 and 18 of the National Water Act (NWA), Act 36 of 1998. The Reserve is not a steady flow, but is a variable flow that mimics natural variations in flows in the river.

An Olifants Comprehensive Reserve Study was undertaken during 1999.

As part of the current study, the Eco-Classification was repeated in 2010. The main objective of redoing the Eco-Classification was to check how the Ecological Water Requirements (EWRs) would be affected by the new classification. It should be noted that the EWRs themselves (i.e. the flow pattern associated with an ecological category at a specific site) were not reassessed and are still the same as determined in the 1999 study.

The rule tables that were developed for the Reserve as part of the 1999 study make provision to release small floods (called freshets) from the dams during the spawning season for fish.

The existing dams do not have sufficient release capacity to release these small floods, and in most cases they can be generated downstream of the dams from the tributaries and the catchment below the dam. These small floods were therefore removed from the rule tables.

Provision has therefore only been made for that portion of the Reserve that is practically implementable. This will reduce the available yield of the whole system by 157 million m^3/a in order to maintain the ecological categories at their recommended levels. The full Reserve with the flood component would have reduced the available yield by 221 million m^3/a.

3.3 CURRENT WATER USE

For the analysis of the surface water and groundwater requirements and availability, the Olifants Catchment has been divided into three management zones as illustrated in **Figure 3.1.**

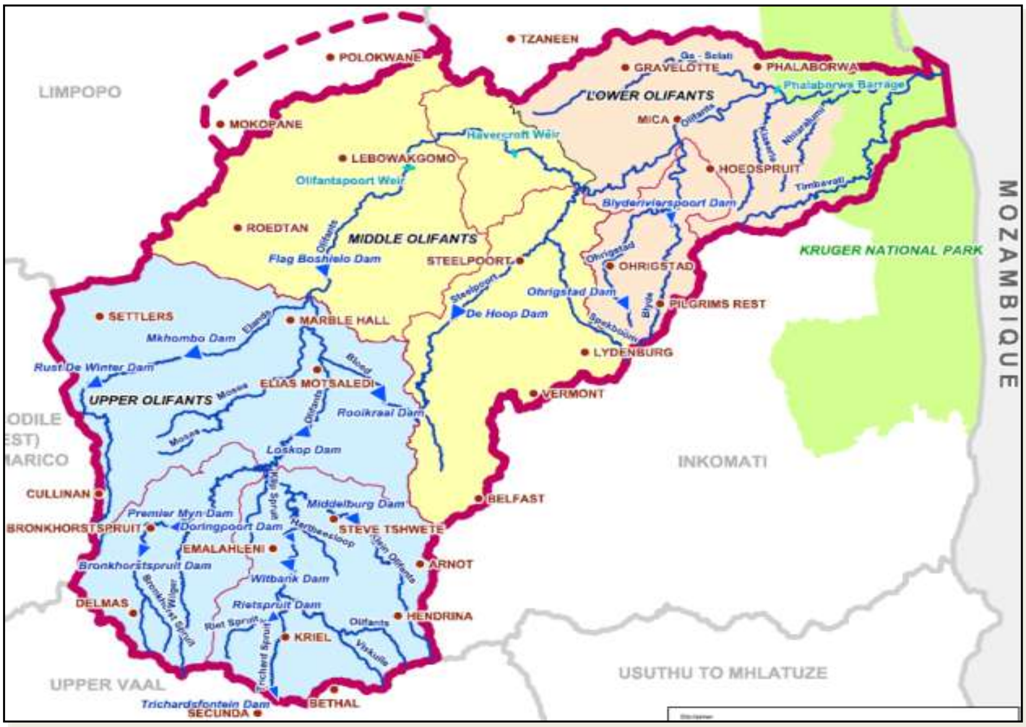


Figure 3.1: Management Zones of the Olifants Catchment

The current water use in the irrigation, domestic and industrial, mining, power generation and forestry sectors is summarised in **Table 3.1**.

Table 3.1: Summary of Water Requirements (Units: million m^3/a)

Management Zone	Irrigation	Urban	Rural	Industrial	Mining	Power Generation	Total
Upper Olifants	249	93	4	9	26	228	**609**
Middle Olifants	81	56	22	0	28	0	**187**
Lower Olifants	156	29	3	0	32	0	**220**
Total	**486**	**178**	**29**	**9**	**86**	**228**	**1016**

Note: The requirements are at different assurances of supply. They have all been converted to a 1:50 year assurance of supply in this table.

3.4 PROJECTED FUTURE WATER REQUIREMENTS

The estimated projected high growth scenario for the Olifants River Basin is shown graphically in **Figure 3.2**.

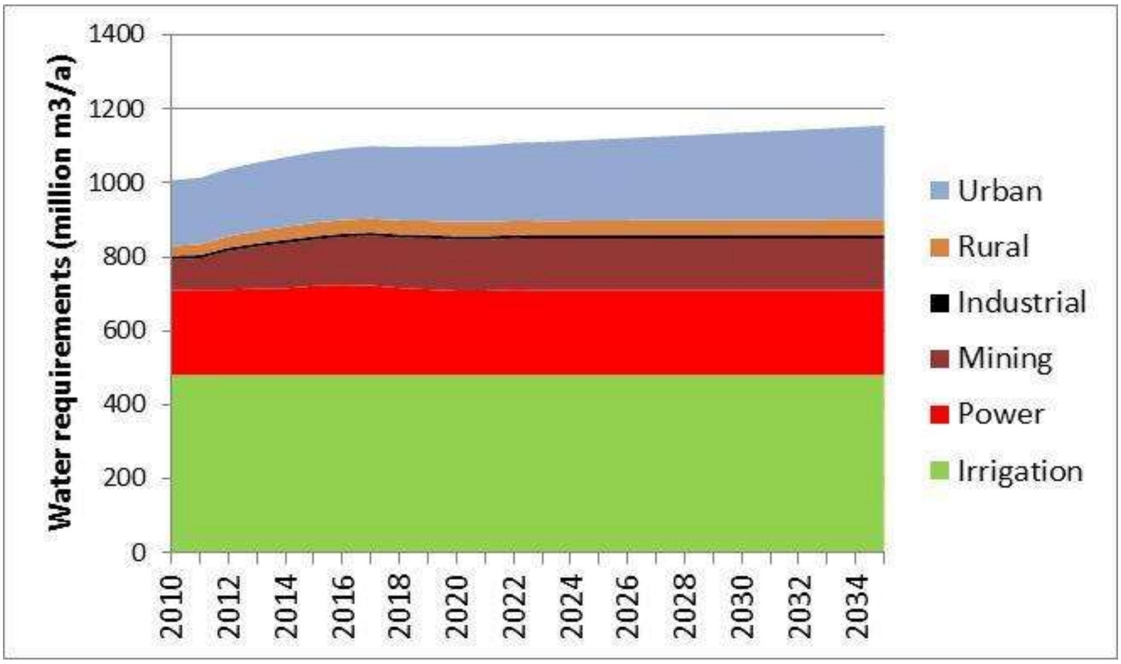


Figure 3.2: High Growth Scenario

The projected total high and low growth water requirement figures for 2035 are shown in **Table 3.2**. These high and low growth water requirement figures have been used for the reconciliation scenarios described in Section 9.

Table 3.2: Total high and low growth water requirements

Sector	Current requirement (2010)	Future requirement (2035)	
		High growth	Low growth
Irrigation	486	486	486
Urban	178	255	221
Rural	29	51	39
Industrial	9	9	9
Mining	86	140	128
Power Generation	228	229	229
Total	**1 016**	**1 170**	**1 112**

It should be noted that low growth scenario is only 5% less than the high growth scenario

3.5 WATER AVAILABILITY

○ **Groundwater**

Groundwater is available throughout the Olifants WMA, although varying in quantities depending upon the hydrogeological characteristics of the underlying formations.
The overall results of the Groundwater Yield Model (AGES, 2008) indicated that there is a surplus of groundwater in the order of 70 million m^3/a.

A hydrogeological yield map of the Olifants WMA is shown in **Figure 3.3**

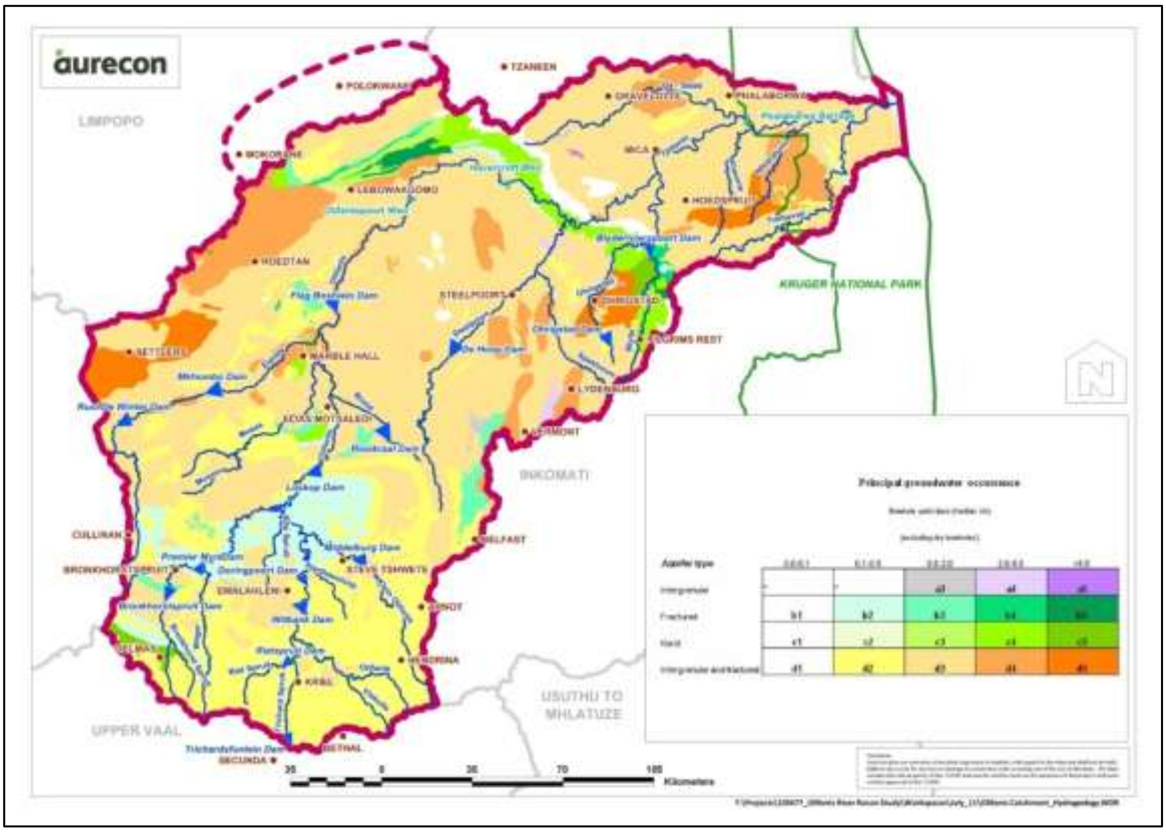


Figure 3.3: Groundwater availability map for the Olifants Basin

Groundwater development in unstressed aquifers must be encouraged. A possible regional water scheme with the Malmani dolomites as resource should be investigated. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River.

- **Surface Water**

The significant dams with their historical and 1:50 year yields are listed in **Table 3.4**. Polokwane and Mokopane are currently supplied by dams that are outside of the study area. These dams and the allocated water to the towns are listed in **Table 3.3**.

Table 3.3: Large dams outside the study area supplying Polokwane and Mokopane

Dam	Town supplied	1:50 year yield allocation (million m^3/a)
Dap Naude Dam	Polokwane	6.2
Ebenezer Dam	Polokwane	12.0
Doorndraai Dam	Mokopane	4.4
	TOTAL	**22.6**

In addition to the yield of the major dams listed in **Table 3.3** there are a large number of farm dams in the Olifants River catchment that contribute to the yield of the system. There are also many water users, mostly irrigators, that abstract water directly from the river and these run-of-river supplies also form part of the water resource equations. The yield related to farm dams and run-of-river abstractions are referred to further as diffuse sources.

Table 3.3 Summarises the diffuse water resources of the study area.

There are several large water transfers from the Upper Komati and the Vaal Systems to supply the six power stations located in the Upper Olifants catchment. These transfers are estimated at 228 million m^3/a.

The incremental future decant also known as Acid Mine Drainage (AMD) from the coal mines in the Upper Olifants Management Zone can be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a and that of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a in total which will become available over a period of 20 years. However this water will require treatment since the river system does not have the capacity to dilute the AMD to an acceptable quality.

Table 3.4: Large Dams in the Olifants River Catchment

Dam	Management Zone	Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
Bronkhorstspruit	Upper	58.9	16.9	23.5
Middelburg	Upper	48.4	12.6	14.0
Wilge	Upper	1.6	6.7	8.0
Witbank	Upper	104.0	29.5	33.0
Loskop	Upper	374.3	161	168
Rust de Winter	Upper	27.3	9.8	11.7
Mkombo with Weltevreden weir	Upper	205.8	11.7	14.0
Flag Boshielo	Middle	1788	53.0	56.0
De Hoop (under	Middle	347.4	98.0	99.0
Ohrigstad	Lower	13.2	18.9	19.8
Buffelskloof	Middle	5.4	14.7	14.7
Der Bruchen	Middle	9.0	8.3	8.3
Belfast	Middle	5.5	5.7	5.7

Dam	Management Zone	Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
Lydenburg	Middle	1.1	2.5	2.5
Blyderivierspoort	Lower	54.6	110	130
Phalaborwa Barrage	Lower	5.7	42	49

Note: Yields are before meeting the EWR water requirements

Table 3.5: Diffuse Water Resources (Units: million m^3/a)

Management Zone	Full Supply Capacity of Minor Dams	Yield of Farm Dams and Run-of-River
Upper Olifants	327	128
Middle Olifants	60	71
Lower Olifants	40	49
Total	**427**	**248**

The projected growth in available yield is shown in **Figure 3.4.**

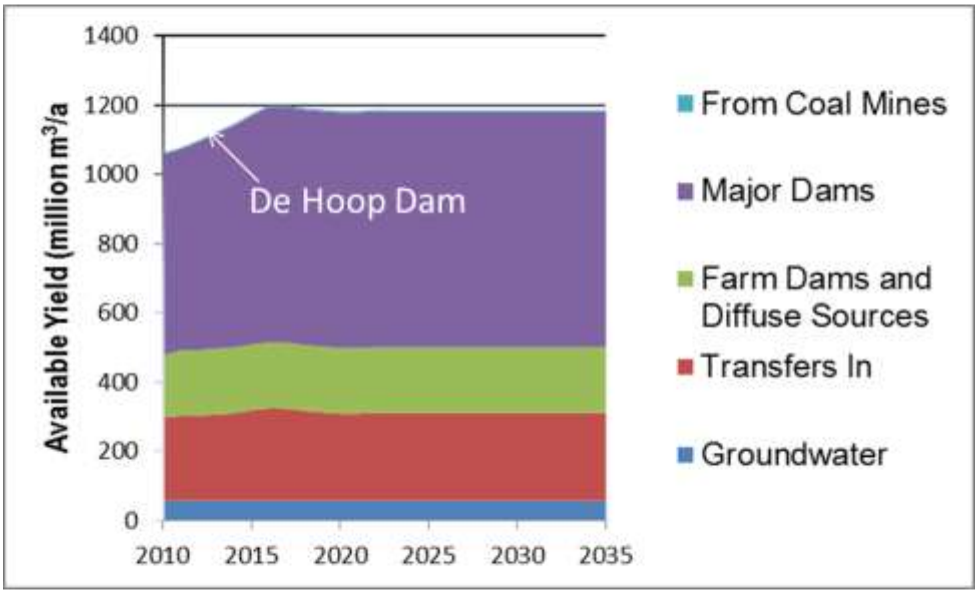


Figure 3.4: Projected growth in system yield

3.6 WATER QUALITY

A separate water quality management strategy is being developed to address the water quality management issues.

The water quality in the study area does not affect the management or availability of the resource (i.e. dilution is not required as yet) although there are limited locations where the water quality is only tolerable and is unacceptable at two sampling points. At many stations however, there is an upward trend in pollution.

Localised water quality problems must be addressed by intensif8ied compliance monitoring and enforcement and by reducing pollution at source.

Despite the fact that the water quality in the system will not influence the water availability, immediate attention should be given to the upward trends shown in
Figure 3.4 so that the sustainability of the resource is ensured.

An issue that will require specific attention is the increasing decant of acid mine drainage. On the one hand it represetns a potential source of water if treated properly, while on the other hand it represents a threat to future water quality if uncontrolled decanting is allowed to occur.

3.7 THE WATER BALANCE

The water balance, based on estimated 2010 water requirements, all at equivalent 1:50 year assurances of supply, is shown in **Table 3.6**. Water deficits are shown in brackets.

Table 3.6: 2010 Water Balance (Units: million m^3/a)

Management Zone	Water Requirement	Total Water Resource	Minimum Flow Rule	Losses	Water Balance
Upper Olifants	609	630	0	0	21
Middle Olifants	187	185	(19)	0	(21)
Lower Olifants	220	248	(19)	(5)	4
Total	**1 016**	**1 063**	**(38)**	**(5)**	**4**

Note: Excluding De Hoop Dam

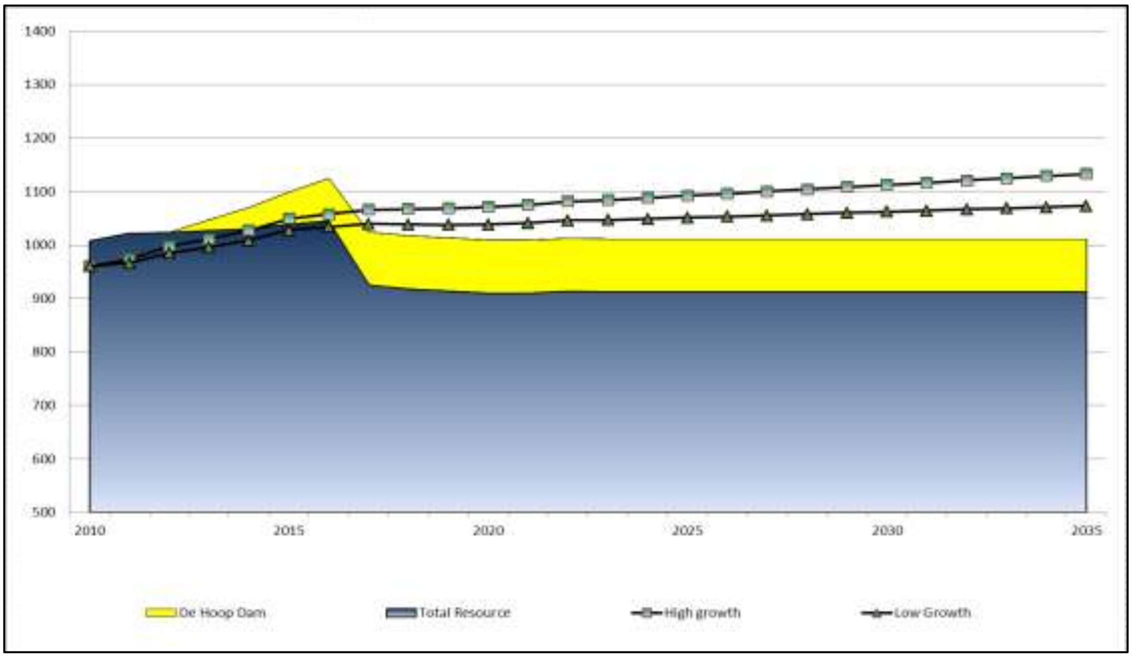


Figure 3.5: Projected Future Water Balance

The projected future water balance is shown graphically in **Figure 3.5** and represents the situation if water requirements are allowed to increase and there is no further water resources development. The increase in the water resource is due to the construction of the De Hoop Dam, phased in over 5 years to allow for filling. The ecological Reserve that reduces the system yield by 157 million m^3/a, was assumed to be operationalized from 2016. This is illustrated by the drop in available yield.

The conclusion can therefore be drawn that the system runs into deficit by 2017, and that by then interventions be required to have been implemented and to be effective.

3.8 POSSIBLE INTERVENTION SCENARIOS

Intervention scenarios comprise combinations of reconciliation options, which can be divided into two main categories, i.e.:

- Reconciliation options which reduces the water requirements
- Reconciliation options which increases the system yield

The following reconciliation options were considered during the study:

- **Reconciliation options that can reduce water requirements**
  - Eliminating unlawful water use
  - Water Conservation and Water Demand Management (WC/WDM) in the irrigation sector
  - WC/WDM in the domestic water use sector
  - WC/WDM in the mining sector
  - Reducing assurances of supply
  - Compulsory licensing
  - Water trading
- **Reconciliation options that can increase water supply**
  - Removal of invasive alien plants (IAPs)
  - Refinements to System operating rules
  - Rainfall enhancement through Cloud Seeding
  - Groundwater development
  - Water Transfers
    - Transferring treated effluent from the East Rand
    - Transferring more water from Vaal Dam
    - Water transfer from the Crocodile (West) River System
  - Dam Options
    - Raising of the Blyderivierspoort Dam
    - New dam downstream of Rooipoort

- New dam on the farm Godwinton in the Olifants River Gorge
- New dam on the farm Chedle in the Olifants River Gorge
- New dam on the farm Epsom in the Lower Olifants River
- New dam on the farm Mica in the Lower Olifants River
- New dam on the farm Madrid in the Lower Olifants River

- Utilising the acid mine drainage (AMD) in the Upper Olifants
- Reusing sewage effluent from towns
- Desalination and transfer of seawater

3.9 BASIS FOR WATER RECONCILIATION

- The following aspects were taken into account and formed the basis for water reconciliation:
  - South Africa will meet its international obligations.
  - The water for basic human needs (BHN) will be supplied.
  - The Reserve is a priority – ecological Water Requirements to meet the recommended ecologic category (REC) will be maintained.
  - All unlawful water use will be eliminated.
  - Water for strategic users for the benefit of the country must receive priority before any other economic development.
  - Water for socio-economic development within the policy parameters of the government will be provided.
  - There will be no increase in total water allocations for irrigation.
  - There will be no increase in forestry areas

- **Yield and cost information of the reconciliation options**

Table 3.6 and **Table 3.7** summarise the yields, costs and unit reference values (URVs) of the different options

Table 3.7: Reconciliation options that will reduce water requirements

Option	Yield/Water Saving (million m^{3}/a)	Cost as NPV (R million)	URV (R/m^3)
Eliminating Unlawful Irrigation use	8.7	12	0.12
WC/WDM: Urban	20	285	1.48
Compulsory Licensing	35	32	0.07
Water Trading – Partial Water Entitlements	35	32	0.07

Table 3.8: Reconciliation options that will increase system yield

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Removal of Invasive Alien Plants	15	120	0.76
Dams:			
Rooipoort Dam	59	1 140	2.14
Dam in Olifants Gorge:			
Godwinton	100	132	0.14
Chedle	100	200	0.20
Dam in Lower Olifants:			
Epsom	286	4 820	1.58
Madrid	440	8 800	1.71
Raising of Blyderivierspoort Dam	110	2 977	2.77
Water Transfers:			
Transfer from ERWAT ∗	38.3	1 123	7.31
Transfer from Vaal Dam ∗	160	3 500	3.60
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	30	1 268	3.82
Crocodile – Flag Boshielo Dam	60	3 926	6.43
Crocodile – Mokopane **	25	3 728	14.51
Transfer from Massingir Dam	50	2 000	4.85
Desalination and transfer of Sea Water	100	12 970	44.45

∗ Excludes cost of early augmentation of the Vaal System (LHFP2 (URV R6.14/m^3))
∗∗ This option could replace the currently planned ORWRDP-Phase 2B
All cost estimates based on 2010 prices.

- **Environmental screening of options**

  Environmental screening was focused on the possible schemes considered in the strategy and aims to:

  - summarise any key environmental or social issues that should be taken into account when considering and comparing options;
  - identify any environmental or social "fatal flaws" or "red flags" associated with any of the projects; and
  - identify environmental authorisations that will be required for any of the projects.

3.10 RECONCILING THE WATER REQUIREMENTS WITH THE WATER RESOURCE

Table 3.9 lists the selected reconciliation options that will reduce water requirements and that are recommended for implementation for the entire Olifants WMA.

Table 3.9: Management Options

Option	Starting Year	Duration (Years)	% Saving	Estimated Saving (million m^3/a)	Comments
WC/WDM Irrigation	2013	5	3.3%	17	Two focus areas: • Improved Irrigation Systems is 19 million m^3/a • Improved conveyances (reducing canal/pipe leaks) is 16 million m^3/a Need to be linked to water trading in order to get the savings back into the system instead of horizontal expansion by the irrigation farmers. Expected savings is 35 million m^3/a, but it is assumed that only 50% of the irrigation farmers will put their savings on offer for purchase.
WC/WDM Urban	2013	5	18.8%	19.8	This saving is regarded as achievable.
WC/WDM Mining	2015	10	6.8%	5	This saving will necessitate transformation from existing processes to alternative processes which will be costly and more time was consequently allowed. Regarded as achievable by the mining industry.
Unlawful Water Use	2012	4	2.1%	8.5	The yield impact as a result of the increased irrigation is 17.4 million m^3/a. This irrigation expansion is not all unlawful as part of it could have expanded through water savings. It was assumed that 50% of this is unlawful. This assumption can only be verified after the completion of the validation and verification processes, but is regarded as a fairly conservative assumption.
			Total saving / yield	**50.3**	

Table 3.10 lists the selected reconciliation options that will increase the system yield. These options are recommended for implementation.

Table 3.10: The most promising and selected reconciliation options that will increase the system yield

Option	Starting year	Duration (years) to full yield	Estimated Yield (million m^3/a)	Comments
Removal of IAPs	2012	23	10.5	Half of the estimated water use by IAPs, i.e. 0.5 x 21 million m^3/a.
Development of Groundwater Schemes	2012	23	35	Half of availability as modelled by AGES. Not all areas are accessible and half of the availability is regarded as exploitable.

Option	Starting year	Duration (years) to full yield	Estimated Yield (million m^3/a)	Comments
Treatment of decanting water from the coal mines in the Witbank Dam Catchment	2015	1	12	Graph in Figure B7 shows the results of a model estimating the future decant from mines in the Witbank Dam Catchment. The additional decant from 2011 – 2015 is 12 million m^3/a.
Treatment of decanting water from the coal mines in the Middelburg Dam Catchment	2030	1	10	Graph in Figure B8 shows the result of a model estimating the future decants from mines in the Middelburg Dam Catchment. The additional decant from approximately 2020 – 2030 is 10 million m^3/a.
Sewage water reuse Polokwane and Mokopane	2012	23	11	Treatment will be necessary. Water can be reused by the mines.
		Total Yield	**78.5**	

A water balance can be achieved with the selcted reconciliation options, which reduce the water requirements in both growth scenarios by about 50 million m^3/a and increase the system yield by approximately 68 million m^3/a. The treatment of decanting mine water has to be done in any event since the owners of the mines are under legal obligation to do this. The development of groundwater schemes is done by various role players on a wide-spread basis.

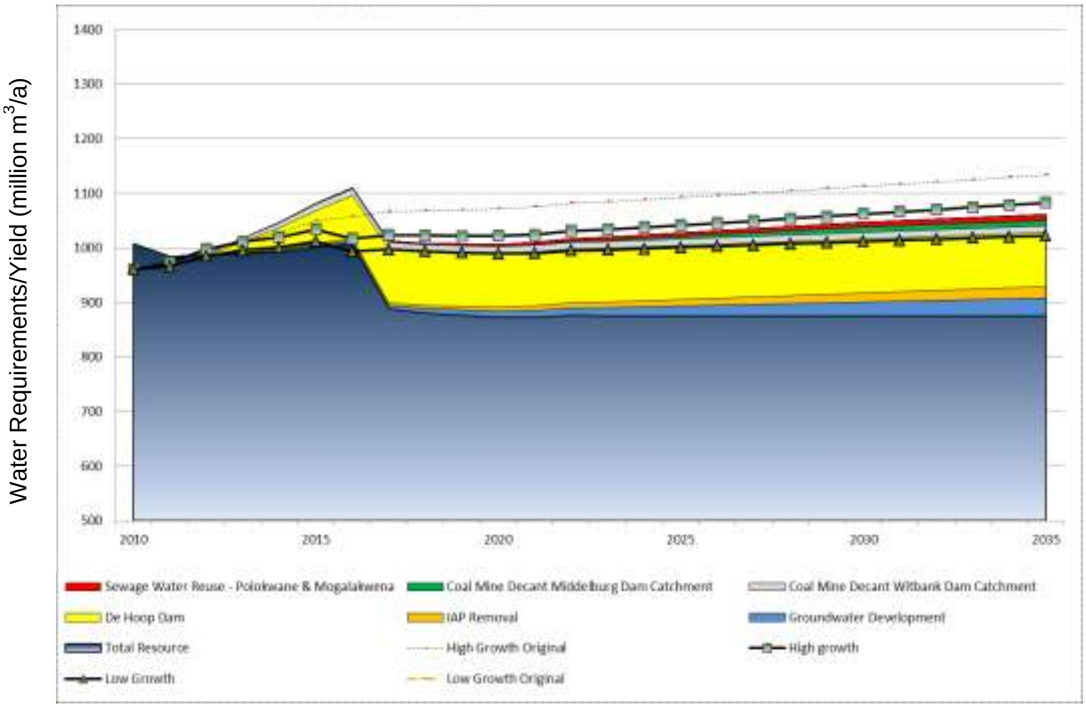


Figure 3.6: Water reconciliation graph for the entire Olifants with management and development interventions

A water balance is achieved with the selected reconciliation options applied. It was assumed that the Reserve will be operationalised in 2016 after De Hoop Dam has filled. Although a water balance is achieved on the catchment as a whole, temporary water shortages might occur within management zones or smaller sub-catchments.

3.11 RISK AND UNCERTAINTIES

The following risks and uncertainties have been identified:

- The extent of unlawful water use is unknown. Until the V&V processes are complete, the water reconciliation strategy will have to rely on the best estimates.

- The possible additional yield which could become available as a result of additional infiltration into existing and decommissioned coal mines is based on the best information available. A study is currently being conducted to improve the confidence in this information but the results of this study were not ready for the purpose of this strategy.

- The results of the Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) need to be verified. It appears as if there could be an over-estimation of IAPs in the Upper Olifants Management Zone, but if correct, it will affect the current water balance negatively in this zone.

- The success of the purchasing of water entitlements (WC/WDM savings) as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements or parts thereof for sale and how much water will eventually be freed up. Care must be taken that irrigation farmers don't cause social upheaval by selling their water entitlements. There must therefore be a well-structured policy in place that will prevent interested sellers from going overboard.

- Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc. This may not necessarily materialise to the extent, or within the time frames that has been assumed in this study.

- The outcome of the Resource Classification process that has now started as a separate study can have a significant impact on the setting of the resource quality objectives and therefore the EWRs. This in turn may have an impact on the assured yield of the system.

3.12 IMPLEMENTATION ARRANGEMENTS

It must be realised from the outset that DWA, as trustee of the country's water resources, is only facilitating the process of water reconciliation planning and that implementation is the responsibility of many more institutions.

- **Institutional Responsibilities**

  The following entities will play a crucial role in all aspects of implementation of the strategy:

  - DWA Regional Office;

- CMA;
- ESKOM;
- Mines;
- Industries
- Municipalities;
- Water Boards;
- Irrigation Boards and Water User Associations;
- Organised Agriculture; and
- Nature Conservation Institutions (e.g. Parks Board).

It is recommended that the Department reviews the priority of this catchment in terms of CMA establishment and put all measures in place to accelerate this process.

- **Funding**

Capital will be required for recycling / treating AMD and to refurbish water supply infrastructure as part of WC/WDM. No other capital expenditure is required to implement the proposed short-term actions. Operational funding from the DWA will be required for some of the other actions.

Capital investment will be required if any one of the structural development options is pursued. A capital project such as a water transfer scheme can be funded from either the fiscus or it can be undertaken by an institution such as the TCTA which also can obtain funds from international financial markets or funding agencies, e.g. The World Bank. Normally the purpose of the project will determine whether the project should be DWA funded or funded from elsewhere. Should the project for example be needed for the water supply to resource poor communities, funding out of the fiscus could be considered by Parliament. Water supply to enterprises that can redeem the capital expenditure themselves would normally be funded off-budget, outside DWA.

3.13 RECOMMENDATIONS TOWARDS IMPLEMENTATION

The recommendations of the strategy document form the core recommendations of the study. They are reflected in Chapter 5 in paragraphs 5.1 and 5.2.

4. CONCLUSIONS AND RECOMMENDATIONS AS PER SUPPORTING REPORTS

4.1 CONCLUSIONS AND RECOMMENDATIONS (INVASIVE ALIEN VEGETATION) (WMA 04/B50/00/8310/3)

The impact of IAPs on SFR, and impact on yield, has been assessed within the Olifants Water Management Area (WMA). This assessment used the latest estimates of the areal extent of IAPs produced by the ARC (ARC, 2009). The IAP areas published by the ARC are for the most part much higher than previous estimates, although a very much lower value for the "Remainder of B51/B52" reduces the total overall difference (see **Table 4.1**). One specific area of uncertainty is the De Hoop Dam catchment. Previous work on IAPs indicated very few IAPs in the De Hoop Dam catchment (total of 8 - 9 km^2), while the ARC estimate this infested area at 300 km^2. Discussions with water resource practitioners, who know the area well, and an examination of Google Earth images, suggest that the original estimates are far more likely to be in line with reality. This puts **all** the ARC estimates for **all** quaternaries into question. The importance of water resource issues and decisions in this catchment is such that we must recommend that IAP data for the entire Olifants system should be re-examined. In the interim the recommended way forward for de Hoop Dam has been to assume no significant IAPs upstream of the dam site. This results in an amended yield reduction estimate as given in **Table 4.1**.

Table 4.1: Impact of IAPs on the Yield of the Olifants System

Sub-catchment	Yield			% Change in yield
	Without IAPs	With IAPs	Impact	
Bronkhorstspruit	23.3	22.5	0.8	3.4
Middelburg	24.5	24.2	0.3	1.2
Witbank	57.5	55.4	2.1	3.7
Loskop	158.7	151.9	6.8	4.3
Rust de Winter	14.5	13.8	0.7	4.8
Mkombo	14.6	13.5	1.1	7.5
Flag Boshielo	67.1	63.9	3.2	4.8
De Hoop	109.2	109.2	0.0	0.0
Blyde River	178.5	172.5	6.0	3.4
TOTAL	**647.9**	**616.5**	**21.4**	**3.3**

The methodology used to estimate the SFR due to IAPs in this study entails the use of flow duration curves of SFR provided by the University of KwaZulu-Natal (Jewitt *et al*, 2009). This method is widely accepted amongst forest hydrologists and has been used in numerous water resources studies. The results appear to be similar to those derived from the WRSM 2000 Model (for upland IAPs), but SFR due to riparian IAPs is somewhat higher in this study than that estimated from WRSM 2000. It is acknowledged, however, that more work into SFR due to riparian IAPs is required and that the methods used in this (and other studies) are not particularly robust. The developers of WRSM 2000 have been informed of their model's shortcoming and it is understood that they are improving this model specifically to deal with riparian IAPs better.

Should the estimated SFR from this study be accepted, the estimates will be disaggregated down to quaternary scale and incorporated into the WRYM setup.

4.2 RECOMMENDATIONS (FUTURE WATER REUSE POSSIBILITIES) (P WMA 04/B50/00/8310/4)

It is recommended to follow the actions described below:

- Proceed with the utilisation of AMD and implementation of further AMD initiatives as indicated in this and the other reports of this series.
- Promote the utilisation of PPP's for the utilisation of AMD in order to unlock the required investment and operational management capacity of industry.
- Extend the current reuse of effluent by the mines, at Mokopane and Polokwane.
- Develop a clear policy, strategy and guidelines for the use and application of all components of non-conventional waters.
- Legislative and implementation tools for the regulating and implementing the use of marginal waters should be established and made available. This should cover aspects such as: water reuse and recycling, implementation of water efficient technology in different industrial sectors, improving water efficiency, etc.
- The Water Conservation and Water Demand Management initiatives identified in the DWA Report "The Development of a Comprehensive Water Conservation and Water Demand Management Strategy and Business Plan for the Olifants and Inkomati WMA's. Industrial component: Power Generation. Situation Assessment", (Prepared by VWG Consulting on behalf of the Directorate: Water Use Efficiency) – should be considered for implementation.
- Rainwater harvesting in the catchment should be promoted and expanded. The subsidy for households for rainwater tanks in the rural areas should be continued and expanded. The use of such harvesting in cities should be promoted and can be even made compulsory for any new town development.
- Opportunities for groundwater recharge should be considered and the approach generally promoted. The feasibility of the implementation of the Godwinton weir to recharge the dolomite aquifer on the escarpment should be investigated further.
- The application of water recycling and internal reuse in industrial process should be continuously be required, promoted, advanced and implemented.
- The possible future implementation of rainfall enhancement should be taken further with a specific project to take the existing research knowledge to the next level and prepare it for possible future implementation.
- The transfer into the catchment of sewage from the Vaal River catchment for reuse in the Olifants catchment need to be considered in conjunction with the strategic constraints of water requirements in the Vaal River catchment itself.

4.3 CONCLUSIONS AND RECOMMENDATIONS (WATER CONSERVATION AND DEMAND MANAGEMENT MEASURES) (P WMA 04/B50/00/8310/5)

A desktop analysis of water use efficiency within the Olifants River catchment and Polokwane (which forms part of the study area) has shown that water use is generally inefficient by accepted benchmark efficiencies. The urban sector is especially inefficient with high to very high losses. Losses within the irrigation sector are generally acceptable, but water could be saved and freed up for other sectors to use through the improvement of the irrigation systems. The mining sector has expressed a willingness to fund such an initiative in return for obtaining an allocation from the water saved. Alternatively, compulsory licensing could be used as a mechanism to re-allocate water saved by the irrigation sector through WC/WDM to other users. The power generation sector, while efficient compared with similar power stations in Europe, makes use of high water-use technology which would be very expensive to replace with dry-cooling systems. Nevertheless, small improvements to the cooling process are possible with some savings in water use. The mining sector is generally very efficient with its water use, but the platinum mine have indicated that they believe a 10% reduction in water demand on all existing operations is possible.

The total saving, per sector, within the study area is indicated in. Based on this, savings could range from, as little as 20 million m^3/annum if the large water losses in the urban sector are addressed, to as much as 99 million m^3/annum if all options are implemented. However, the cost of all these options need to be weighed up in terms of cost-benefit and compared with cost-benefit estimates of other reconciliation options.

Table 4.2 summarises possible water savings through various WC/WDM measures within the study area.

Table 4.2: Summary of possible water savings

Sector	Current water requirement (million m^3/a)	Estimated saving (million m^3/a)	Comment
Urban	140.4	32.1	Achievable
Rural	29	0	Problematic due to low levels of service
Irrigation • Improved irrigation systems • Improved conveyances	486	19 16	Requires willing buyer/willing seller Very costly
Power generation	228	27.3	Very costly
Mining	86	5	
Industrial	9.0	~0	
Total	**978.4**	**99.4**	

4.4 RECOMMENDATIONS (WATER REQUIREMENTS) (P WMA 04/B50/00/8310/6)

The assessment of the water requirements has the most significant impact on the water balance. In this regard the uncertainties of the projected water requirements need to be well understood.

While the water requirements and water resources presented in this report are based on the latest information available, derived from numerous recent hydrological and water resources studies as well as new information that has been sourced during the course of this study, the following uncertainties are noted:

- Water use by irrigators not located within irrigation boards.
- River losses
- Water use by the coal mining sector in the Upper Olifants river catchment

It is recommended that:

- All water use, but especially water use by the irrigation sector, is verified.
- River losses are quantified through detailed hydraulic studies.
- Water use by coal mines is monitored.

4.5 CONCLUSION (WATER QUALITY) (P WMA 04/B50/00/8310/7)

The water quality in the Olifants River System is generally fit for use, with the exception of the Middelburg Dam (Station B1H004) where the pH, nitrite/nitrate and ammonia levels are within the unacceptable range. Some stations (stations B1H020, B1H019, B1H005 in the Witbank Dam Catchment, stations B1H012 in the Wilge River and Loskop Dam Catchment and station B3H002 in the Middle Olifants Catchment) have sulphate levels that are within unacceptable ranges. The phosphates are slightly high throughout the study area.

Despite the fact that the water quality is generally such that it is fit for use, there are a significant number of localised water quality problems, especially in the upper parts of the catchment and around Phalaborwa. Most of these have to do with pollution or poor on-site management of water, and can (and should) be addressed at source.

An exception to this is the question of acid mine drainage in the coal mining area. This is a large-scale problem that will have to be addressed by desalinating the water. This will on the one hand present an additional source of water in the urbanised and industrialised upper part of the catchment, while on the other hand will prevent the water quality in the Loskop Dam from deteriorating to the point where the fitness for use to downstream users is compromised.

4.6 THE PRELIMINARY SCREENING WORKSHOP FINDINGS AND RECOMMENDATIONS (PRELIM SCREENING OPTIONS REPORT) (P WMA 04/B50/00/8310/8)

As a general trend, the options with relative low capital and/or operating cost and low unit reference value (URV) contributed little to reducing the water yield deficit, whilst the capital/operating intensive options were more effective in terms of yield contribution.

An exception to this trend was the Optimising Assurance of Supply option, where it appeared that, with a little effort and cost, a significant quantity of water can become available. This needs to be investigated further.

The following recommendations are made:

- That 20 options be investigated further,
- That all options with low scores on criteria be carefully investigated to determine whether these criteria will prohibit the option from further investigation,
- That the options be ranked in order of preference,
- That the “quick win” options with less investment be identified to alleviate the immediate needs,
- That further investigation work for the longer term options that will be required as part of this study be identified and scheduled for investigation in time for the Final Reconciliation Strategy, and
- That the workshop results be conveyed to the broad public by means of a Newsletter.

4.7 CONCLUSIONS AND RECOMMENDATIONS (YIELD ANALYSIS OF DE HOOP AND FLAG BOSHIELO DAMS) (P WMA 04/b50/00/8310/16)

There are many parameters that affect the yield of a dam, such as the natural hydrology, water use upstream of the dam, and the manner in which the dam is operated. The sensitivity of the yield of the De Hoop and Flag Boshielo Dams has been investigated, and through numerous comparative analyses, the reasons why the estimated yields of these dams changed across a range of water resource studies were determined. The updated yield models were then used to provide new estimates of the yields of these dams. The yields of the De Hoop and Flag Boshielo Dams are now estimated to be as follows:

Table 4.3: Yield of De Hoop and Flag Boshielo Dams

Dam	ORWRDP	Recon Study (2010)	
	1 in 50 Year Yield (million m^3/a)	**Historical Firm Yield (million m^3/a)**	**1 in 50 Year Yield (million m^3/a)**
Flag Boshielo	84	53	56
De Hoop	80	65	66
Total	**164**	**118**	**122**

However, not only is there a measure of uncertainty in all the parameters influencing the yield of a dam, these factors also changes over time and hence, the yield of dams is likely to change. In order to realise the yields calculated during the planning phase of a dam, the catchment managers should be made aware of the assumptions made and operate the catchment accordingly. The important assumptions to note are as follows:

- The De Hoop Dam will be very sensitive to any additional water use upstream of the dam. In order to the secure the yield of the dam; a moratorium should be placed on the issuing of new licences upstream of the dam. The yield will need to be re-calculated should the verified water use prove to be different from the water use obtained from the Validation Study (DWAF, 2006a).

- The yield of the Flag Boshielo Dam is sensitive to the operating rule of Loskop Dam with respect to water supply to the IBs. The assumption has been made that the current demands will be supplied and not the full allocations. Further, it is assumed that return flows from irrigators will return to the river and become available as allocable yield from the Flag Boshielo Dam. Hence, if irrigators supplied from Loskop Dam improve their efficiency some of the saved water should be returned (i.e. allocations reduced) to compensate for the loss of return flows.

- The Water Court Order that requires a release of 8.16 million m^3/a from Loskop Dam must be reinstated and measures introduced to ensure that riparian irrigators between Loskop and Flag Boshielo Dams do not use this water unlawfully.

- The lawfulness of the irrigation use (outside of the IB) upstream of the Flag Boshielo Dam needs to be verified.

4.8 CONCLUSIONS AND RECOMMENDATIONS (MANAGEMENT AND DEVELOPMENT OPTIONS & COST ESTIMATES) (P WMA 04/B50/00/8310/9)

Table 4.4: Summary of options considered

Option	Yield ($x10^6$ m^3/a)	Capital Cost (R million)	URV (R/m3)
Rooipoort Dam	59	1 140	2.14
Dam in Olifants Gorge:			
Godwinton	100	132	0.14
Chedle	100	200	0.20
Dam in Lower Olifants:			
Epsom	286	4 820	1.58
Madrid	440	8 800	1.71
Raising of Blyderivierspoort Dam	110	2 977	2.77
Transfer from ERWAT ∗	38.3	1 123	7.31
Transfer from Vaal Dam ∗	160	3 500	3.60
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	30	1 268	3.82
Crocodile – Flag Boshielo Dam	60	3 926	6.43
Crocodile – Mokopane **	25	3 728	14.51
Transfer from Massingir Dam	50	2 000	4.85
Desalination of Sea Water	100	12 970	44.45

∗ Excludes cost of LHFP (URV R6.14/m^3)

∗∗ This option could replace the currently planned ORWRDP-Phase 2B

All cost estimates based on 2010 prices.

The following conclusions can be made:

- The Rooipoort Dam has high social costs and is located on a stretch of river whose flow is already much reduced. Much of its yield would therefore be allocated to meeting the EFR.

- The uncertainty regarding the suitability of the dolomitic foundations and basin make the technical feasibility of a dam in the Olifants Gorge questionable. A detailed geo-hydrological study would be required before any of these dams could be considered further.

- Dams in the lower Olifants River, as well as the Blyderivierspoort, are poorly located in relation to the demands and the cost of pumping this water to the users would be exorbitant.

- Transferring treated effluent from the ERWAT WWTW or raw water from Vaal Dam would both exacerbate water shortages in the Vaal river basin, for which Phase 2 of the Lesotho Highlands Water Project is currently being planned. The URV of that scheme is currently estimated at R6.14 /m3, which must be added to the cost of transferring the water to the Olifants river.

- Transferring water from the Crocodile (West) river to the Olifants river seems very favourable. While that water was till recently allocated to Eskom’s proposed coal burning power stations at Lephalale, those stations are no longer envisaged in Eskom’s new strategy, so the water has become available. The delivery point which has been costed, namely Flag Boshielo Dam, is well located in relation to the expected growth in water demand. A detailed pre-feasibility study of possible options and how they would complement the ORWRDP project, is required before any firm decision can be made as to exactly how this water should be developed.

- Transferring water from Massingir Dam would benefit only the KNP, and there is no certainty that the scheme would be considered to have positive environmental impacts. The necessary negotiations with Mozambique would also be a serious complication. This alternative is not considered to be a viable option.

- Desalination of sea water and pumping it from the coast is not considered to be viable in the short to medium term, and the costs are presented only to give an indication of what might eventually be necessary should water demands continue to grow beyond the planning horizon of this study.

- The reducing of assurances of supply for the irrigation sector from the current 80% should be investigated and a consultation process should be initiated.

4.9 CONCLUSIONS (GROUNDWATER OPTIONS REPORT) (P WMA 04/B50/00/8310/10)

The following conclusions are made:

- The availability of groundwater resources for abstraction is controlled by the aquifer characteristics of permeability and storage. The aquifers in the Olifants River Catchment are divided into three main types namely, inter-granular and fractured, fractured and karst or only fractured. All aquifers are capable of providing more than the basic human (BHN) need of 25 ℓ per head per day.

- Groundwater quality is impacted by mining, agriculture and sanitation as indicated by high EC and nitrate content. Natural occurrence of high fluoride also impact on water quality for human consumption.

- Groundwater data is limited in the Gauteng and Mpumalanga Provinces as no GRIP project has been implemented to update the present quantity and quality groundwater data.

- The following six stressed areas were identified during groundwater resource investigations:

    - Delmas Dolomite Aquifer;
    - Zebediela Dolomite Aquifer;
    - Springbok flats Karoo Aquifer;
    - Highveld Coal Mining Area;
    - Steelpoort Mining and Community Supply Aquifers; and
    - Kruger National Park and Bushbuckridge areas.

- Groundwater recharge was determined using the Groundwater Yield Model (864 million m^3/a) and the GRDM software (2 015.2 million m^3/a). The more conservative values must be used until the results of the current study by SRK, i.e. the validations of their estimates are available, and a comprehensive groundwater reserve is determined.

- Both recharge calculations indicated that additional groundwater resources are available for development.

- Three groundwater development options are considered to improve the available water resources in the future. The options considered are:

    - The management and control of over-exploited groundwater resources;
    - The development of under-exploited groundwater resources; and
    - Conjunctive use of groundwater and surface water.

4.10 CONCLUSIONS (ECO-CLASSIFICATION OF THE 1999 ASSESSMENT AT EWR SITES IN THE OLIFANTS RIVER (WMA4) (P WMA 04/b50/00/8310/18)

Below follows a summary table indicating the 1999 EcoStatus, the 2010 EcoStatus, the change as well as which 1999 EC's EWR rule (flow requirements) must be used for yield modelling and planning.

Table 4.5: Table of all EWR sites indicating overall change and the appropriate EWR rule to use for yield modelling

EWR site	1999 PES	2010 PES	1999 REC	2010 REC	Change	EWR rule
1	D	D	C	D	-	D
3	D	D	C	D	-	D
4	B	C	B	B	-	B
5	C	C	B	C	=	C
6	E	C/D	D	C/D	+	C
8	E	C/D	D	C/D	=	D
9	D	C/D	D	C/D	=	D
12	B	B/C	B	B	=	B
13	C	C	B	C	=	C
15	C	C	B	B	=	C
16/17	C	C	B	B	=	B

- *The column named "Change" denotes a real change in the state of the aquatic ecology as opposed to a change in the PES due to revised methodology.*

- *Sites 16 and 17 are essentially the same site (close to each other) but were used to model different flow conditions*
- *=:1999 EC is the same as 2010*
- *--: Large scale degradation has taken place; -: Small scale degradation has taken place*

- *++: Large scale improvement has taken place; +: Small scale improvement has taken place*

The following conclusions can be made from the above table:

- EWR 1 (Olifants River) and EWR 3 (Klein Olifants River) above Loskop Dam both show deterioration. The major reasons appear to be worsening water quality and the biological responses to this. The water quality problems appear to be due to the problems regarding sewage works that do not have the capacity to handle the current load.

- EWR 4 (Wilge River): This EWR site used to be in a very good condition and is of high EIS. There has since apparently been a marked degradation in instream condition. As it is known that mining (especially around the Saalboomklapspruit) has caused significant problems in the past, it is assumed that these associated water quality problems are the cause. Recent monitoring on the affected tributaries have however showed some improvement and it hoped that if the mines follow mitigation measures and continue monitoring, there might be a positive trend.

- EWR 6 (Elands River): The Elands River is the only site that shows an improvement (instream) and this is due to the recent change in operation of the Renosterpoort Dam. It is uncertain why the operation has changed and whether this is permanent.

4.10.1 RECOMMENDATIONS ECOCLASSIFICATION OF THE 1999 ASSESSMENT AT EWR SITES IN THE OLIFANTS RIVER (WMA4) (P WMA 04/B50/00/8310/18)

The work undertaken for this study was based in most cases on one survey during the last 11 years. This survey was an extremely rapid survey as part of the 2010 reconnaissance survey and only 1 hour maximum was allowed on site. The results are still of moderate confidence (Table 13.3). It is however essential that monitoring according to the Ecological Water Resources Monitoring Programme be implemented ASAP. This river is one of the key rivers in SA in terms of water allocation and is also a highly ecological (and in terms of Goods and Services) important. Monitoring should have been implemented immediately after the 1999 EWR study as all data collated during that survey can be seen as historical only. A new baseline has to be set and effectively, the EWR has to be recalculated. The additional motivation for this is the out of date methods that were applied during 1999 and the significant improvement in methods resulting in more accurate and useful results.

Confidence were assessed for the 2010 PES as well as the assessment of whether the ecological state has changed between 1999 and 2010. The confidence score is based on a scale of 0 – 5 and colour coded where:

Table 4.6: Confidence evaluation

0 – 1.9: Low | 2 – 3.4: Moderate | 3.5 – 5: High

EWR sites	2010 PES confidence	Confidence in change from 1999
EWR 1	3.0	2.5
EWR 3	3.0	2.7
EWR 4	3.2	3.5
EWR 5	3	2.3
EWR 6	2.7	3.0
EWR 8	3.1	3.3
EWR 9	2.8	3.7
EWR 12	3.1	3.7
EWR 13	3.0	3.3
EWR 15	3.1	3.5
EWR 16/7	2.7	3.7

4.11 SUMMARY AND CONCLUSIONS (EVALUATION OF ECOLOGICAL CONSEQUENCES OF VARIOUS SCENARIOS)

The various scenarios are summarised in **Table 4.7** and recommendations are with regards to an optimised modelling scenario. In conclusion, it is essential that the REC be provided at EWR 4 (Wilge River) and at EWR 16/17. Note that EWR 16/17 is the driver site and this will also result in the REC being met at EWR 15. These are the only sites that require changes to present operation of the system in terms of increased flow releases to achieve the ecological objectives. Recommendations to change the operation of the Blydepoort and Renosterkop Dam were also made as these could, with minimal impact on yield, achieve the ecological objectives. This is especially important for the Blyde River which has a HIGH EIS and as it has now shown to be degrading.

Table 4.7: Summary of ecological consequences to various flow scenarios and recommendations regarding an optimised scenario

EWR Site	SC 3	SC1a	SC1b	SC 2	Present operation	Recommendations of Optimised Scenario	Conclusion
1	X	X	X	X	✓	Maintain present operation according to the revised more realistic hydrology	Take out of model
3	✓	✓	✓	✓	✓	Maintain present operation	Take out of model
4	X	✓	✓	X	X	Improve to the B.	Include the B EWR in the model
5	✓	✓	✓	✓	with changes	As invertebrates have degraded and the fish is 1 % away from degradation, it would be necessary to at least never have zero flows from Loskop.	Remove EWR as demand but provide a minimum of .5 m^3/s when there would have been zero flows.
6						Address operation from dam	Take out of model at this stage.
8	X	✓	✓	X	✓	Maintain present day hydrology according to the revised hydrology	Take out of model. Note: any decrease in flow from current will drop the category at this

EWR Site	SC 3	SC1a	SC1b	SC 2	Present operation	Recommendations of Optimised Scenario	Conclusion
							site and very definitely US of the Mohlapitse.
12						Address operation from dam	Address operation of the dam. This will probably not impact on yield, i.e. take out of model
13 & 15						See 16	As long as EWR 16's water is provided from upstream of the barrage (i.e. Blyde, Olifants and other tribs), then 13 should be catered for.
16/17	X	✓	X	X	X	Provide REC*	Include in model as driver site.

4.12 CONCLUSION AND RECOMMENDATIONS (ENVIRONMENTAL SCREENING REPORT)

Some of the options under consideration involve significant negative environmental impacts; however, these can be mitigated. The options involving new dams raise potential red flags that should be investigated further.

4.13 RECOMMENDATIONS (PRELIMINARY RECONCILIATION STRATEGY REPORT) (P WMA 04/B50/00/8310/14)

The following is recommended:

- The uncertainties listed in section 12 of the Preliminary Reconciliation Strategy Report need to be investigated further in order to base the Final Strategy on improved information.
- A thorough investigation into the Reserve is recommended, as a lesser effect of the implementation of the Reserve could render a further large augmentation option after De Hoop Dam unnecessary (See Scenario 3).
- All the possible management options to reduce water requirements should be implemented as soon as practical.
- The WCDM for irrigation and mining should be linked to compulsory licensing or the compulsory levy for purchasing water entitlements. In the case of compulsory licensing, the validation and verification process needs to be complete.
- The option of implementing a compulsory levy to fund the purchase of water from willing sellers could also be explored. Compulsory licensing must, however be initiated. Should a compulsory levy be accepted and implemented, this would reduce the impact of compulsory licensing.
- The validation and verification process should be accelerated. Both the compulsory licensing and the completion of eliminating of unlawful water use are dependent on this task.
- The establishment of a catchment management agency for the Olifants River has to be accelerated.

- Groundwater development in unstressed sub-catchments must be encouraged. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River.
- Bulk water abstraction from the Malmani aquifer where it crossed the Olifants River must be investigated together with the possibility of artificial recharge with surface water.
- An indicative conclusion at this point in time is that either the Godwinton or Chedle dam sites would provide the most economical development option; these are well located in relation to the mining developments in the Middle Olifants River. Further investigations into these dam sites are recommended.
- Raising of the Blyderivierspoort Dam and new dams at Rooipoort and Madrid (representing the three sites in the lower Olifants) are all very costly, and other than Rooipoort, are not suitably located to serve any user except the KNP.
- The two water transfer options also seem too costly despite the advantage of bringing water to the headwaters of the catchment. A possible water transfer from the Crocodile system, which has only recently become an option as a result of lower water demand from the Crocodile than originally estimated, has not yet been investigated. It is recommended that its investigation is included in the final reconciliation strategy.
- Water trading should be encouraged, with the State providing the market and buying out water to meet the needs of the Reserve. This would provide water at a far lower cost than the construction of an additional dam, or the importation of Vaal River water.
- The impacts of all interventions must be continuously monitored. Given the many uncertainties it is essential to stay ahead, respond rapidly, and to manage the system as indicated by successes or failures in measures applied.

4.14 CONCLUSION AND RECOMMENDATIONS (LIABILITY OF THE RESPONSIBLE AUTHORITY FOR CHANGES IN YIELD ASSESSMENT) (P WMA 04/b50/00/8310/14)

The inclusion of water use data in the official studies and reports on water resources development in the Olifants WMA, whether this data was derived from field surveys, official sources or databases, or other sources, remains merely a version of what water uses are exercised, and cannot serve as official condonation of unlawful water uses.

Water use rights can only be acquired by authorisation under the Act (including licensing, water transfers or compulsory licensing) or by the verification of ELWU’s. Unless these mechanisms have duly been used to verify or authorise water uses under the Act, the water uses which are exercised, whether registered or not, may be continued as ELWUs, but are at all times subject to verification or licensing. This is irrespective of whether or not the uses are mentioned in reports or used as the basis to determine dam yields, hydrology or catchment data.

The RA is bound to water uses only once these uses have been officially confirmed by proper verification in terms of the prescribed processes, or by proper authorisation in terms of the different licensing processes. Until then, all uses are indeed lawfully exercised, yet they are merely ELWUs and therefore of temporary nature.

The consultants undertaking the different dam yield assessments and hydrology studies, have referred to the problems and complexities of confirming water uses, and have repeatedly recommended the verification or compulsory licensing of water uses upstream of the respective dams, in order to attain legal certainty.

It is submitted in conclusion that the RA is not legally bound to supply water in accordance with water use data quoted in official water resources management reports and studies used for yield assessments or other purposes. The RA is therefore not liable for claims by users that the data be confirmed as permanent water use rights.

It is recommended that the verification and compulsory licensing of water uses be undertaken as a matter of urgency, in order to determine the correct water yields for the WMA. Without these, the volume of water lawfully used by irrigators and other users upstream of the dams will remain uncertain, with the result that DWA cannot guarantee water yields.

5. CONSOLIDATED RECOMMENDATIONS

5.1 STRATEGIC RECOMMENDATIONS TOWARDS IMPLEMENTATION

The following is recommended:

- All the possible management options to reduce water requirements should be implemented as soon as practical, except for compulsory licensing which can be regarded as a contingency measure, should the reductions in water demand not be achieved.
- The WC/WDM for irrigation should be linked to the purchase of water entitlements so that the save water can be put on sales offer.
- The validation and verification process should be accelerated. Various interventions are dependent on this process, e.g. purchase of water entitlements, water trading, compulsory licensing and eliminating unlawful water use.
- A policy and guideline document on the purchase of partial water entitlements (save water through WC/WDM measures) are urgently required and should be produced by DWA during the first year of implementation 2012.
- The establishment of a catchment management agency for the Olifants River should be accelerated.
- Groundwater development in unstressed aquifers must be encouraged. A possible regional water scheme with the Malmani dolomites as resource should be investigated. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River.
- The impacts of all interventions must be continuously monitored. Given the many uncertainties it is essential to stay ahead, respond rapidly, and to manage the system as indicated by successes or failures in measures applied.

5.2 RECOMMENDATIONS FOR FURTHER WORK

The following further work is recommended:

- The possibility of adopting lower assurances of supply for irrigation need to be negotiated with irrigation boards, water user associations and farmer associations. A policy document with an attractive incentive should be developed in cooperation with the Department of Agriculture.
- Operating rules for possibly operating Middelburg Dam, Witbank Dam, Loskop Dam and Flag Boshielo Dam and De Hoop Dam as a system should be investigated.

5.3 FURTHER GENERAL (SECONDARY) RECOMMENDATIONS

- The current efforts on the reduction of invasive alien vegetation should be continued.
- **Proceed with the utilisation of AMD and implementation of further AMD initiatives as indicated in this and the other reports of this series.**
- **Promote the utilisation of PPP's for the utilisation of AMD in order to unlock the required investment and operational management capacity of industry.**
- **Extend the current reuse of effluent by the mines, at Mokopane and Polokwane.**
- Legislative and implementation tools for the regulating and implementing the use of marginal waters should be established and made available. This should cover aspects such as: water reuse and recycling, implementation of water efficient technology in different industrial sectors, improving water efficiency, etc.
- **Rainwater harvesting in the catchment should be promoted and expanded. The subsidy for households for rainwater tanks in the rural areas should be continued and expanded. The use of such harvesting in cities should be promoted and can be even made compulsory for any new town development.**
- The application of water recycling and internal reuse in industrial process should be continuously be required, promoted, advanced and implemented.
- The possible future implementation of rainfall enhancement should be taken further with a specific project to take the existing research knowledge to the next level and prepare it for possible future implementation.
- In terms of improved management of water utilisation it is recommended that River losses are quantified through detailed hydraulic studies and water use by coal mines is monitored.
- **The yield of De Hoop Dam is sensitive to additional water use upstream of the dam. In order to secure the yield of the dam; a moratorium should be placed on the issuing of new licences upstream of the dam.**

ANNEXURE A:
EXTENT OF INVASIVE ALIEN PLANTS AND REMOVAL OPTIONS

Alien vegetation, especially large invasive trees such as eucalyptus, pines and wattles, is known to reduce streamflow to less than that which would occur under naturally vegetated conditions. This is due to the additional biomass and water use attributed to alien species. One of the options to consider in finding solutions to the water shortages within the Olifants River catchment is the removal of Invasive Alien Plants (IAPs), thus increasing the runoff from the catchment and the yield of the dams. Hence, an assessment of the streamflow reduction due to invasive alien plants (IAP) has been carried out as part of the Olifants Reconciliation Strategy Study. This report documents the results of this analysis.

While previous water resource studies have assessed the impact of IAPs on the water resource, this Reconciliation Strategy (i) makes use of new information on the extent of IAPs provided by the Agricultural Research Council (ARC), and (ii) provides an evaluation of the various models and methods used by Working for Water and other researchers in estimating streamflow reduction due to IAPs within the Olifants River catchment. It is concluded that the Working for Water assessment for the Blue Ridge mine water trade greatly over-estimates water use by IAPs (see also Appendix A). This was primarily because the extent of riparian invasion, and consequent high levels of water use, is over-estimated.

It would also appear that the ARC areal estimates of invasion are greatly over-estimated in the catchment of the de Hoop Dam, probably also for Loskop and Witbank Dams, and quite probably far from accurate in other quaternaries. Given that actual area of invasion is the first and foremost parameter in estimating water use, and given that errors and uncertainties in these estimates are greater than uncertainties in the application of different water use models, it is recommended that a specific study be undertaken to verify existing figures. This could be undertaken by experts at desktop level, over a few days, using existing areal and satellite imagery.

The methodology used in this assessment of the Olifants River catchment is derived from the research carried out by the University of KwaZulu-Natal which culminated in the so-called Gush tables. These tables are also applicable to upland alien vegetation. Riparian IAPs will use much more water than upland IAPs due to increased access to water. Models used by Working for Water indicate streamflow reduction varying from 200 to 500 mm/a depending on which model was used. For the purposes of this Olifants assessment, the streamflow reduction due to riparian IAPs was set at 300 mm/a and assumed to vary from month to month with the evapo-transpiration rate.

From a water resource management perspective the real problem with IAPs is not streamflow reduction per se, but the extent to which these invasions are reducing the available yield from dams. This yield impact was assessed using a simplified yield model - and the results of this analysis are summarised in **Table A1** below. However it must be cautioned that errors in estimates of actual invaded area will be carried over into both errors in estimates of both streamflow reduction and available yield from dams.

Table A1: Summary of streamflow and yield reduction due to IAPs

Catchment	Streamflow Reduction (million m^3/a)		Reduction in yield (million m^3/a)
	Upland	Riparian	
Bronkhorstspruit	1.0	0.2	0.8
Middelburg	0.9	0.1	0.3
Witbank	7.4	0.2	2.1
Loskop	20.0	1.4	6.8
Rust De Winter	1.2	0.5	0.7
Renoster	0.5	0.0	1.1
Flag Boshielo	4.1	1.2	3.2
B51-B52	0.8	0.0	
B71	1.5	0.0	
De Hoop	10.5	0.4	0.0
B41-B42	5.0	0.0	
Orighstad	0.0	0.0	
Blyde	7.6	0.3	6.0
B72	1.2	0.0	
B73	0.0	0.0	
TOTAL	**61.7**	**4.3**	**21.4**

Recommendations from this study are:

(i) The use of improved methodologies to estimate water use by Invasive Alien Plants will give better estimates of actual water use (SFR) and of the utilisable yield of dams.

(ii) Past estimates of water use by IAPs appear to over-estimate this impact, primarily due to over-estimates of the impact of Invasive Alien Plant within the riparian zone. These have been corrected.

(iii) Base data for actual areas of invader plants must be improved. A specific study for the Olifants River Catchment, commencing with the catchment area above the de Hoop dam should be initiated. This can be undertaken by experts at desk-top level in a matter of days.

(iv) Best current estimates on areas of invasion suggest insignificant invasion in the catchment of de Hoop Dam and a reduction of previously calculated impact to zero.

ANNEXURE B:
FUTURE WATER REUSE POSSIBILITIES

The Olifants River Catchment is located within the provinces of Gauteng, Mpumalanga and Limpopo and covers an area of approximately 54 550 km^2. The catchment has been divided into three sub-catchments, namely the Upper Olifants, Middle Olifants (Incorporates the Steelpoort River), and the Lower Olifants.

The study area consists of the Olifants River Catchment and its immediate supply zone. Hence, the urban areas of Polokwane and Mokopane have been included in the study area. This study area is collectively referred to as "the catchment" in this report.

The catchment is considered a stressed catchment. In order to contribute towards improving the water balance situation in the catchment and the livelihood of people in the catchment, measures to reuse water in the catchment must be considered. This report focuses on the existing use of non-conventional water and identifies future potential use of- non-conventional water within the Olifants River Catchment. The objective is to improve water efficiency and recycling and where possible contribute towards the yield in the catchment.

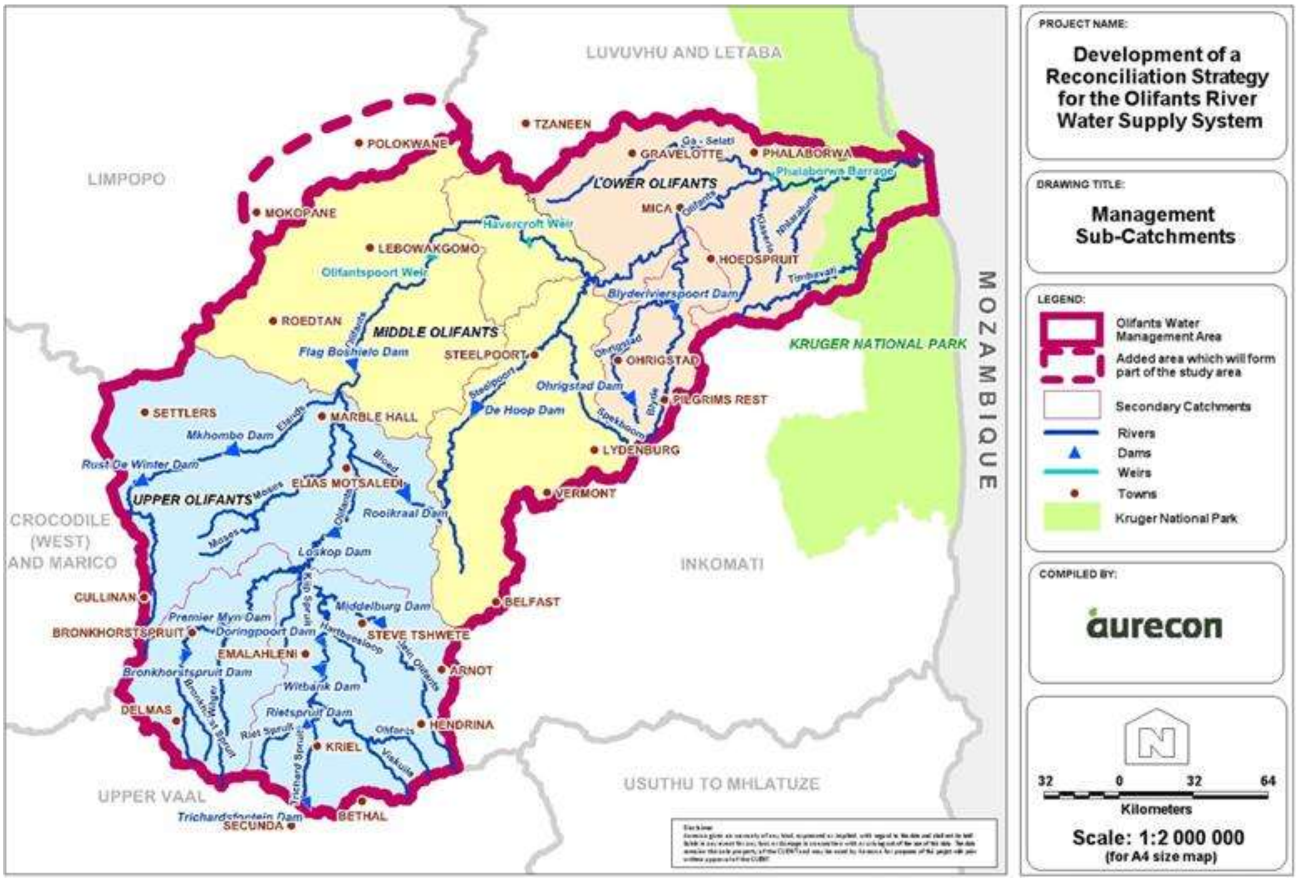


Figure B1: Map indicating the location of the Olifants River Catchment

WATER REUSE

The reusing and recycling of water provides greater utilisation of water and improves water quality in the system. Non-conventional water, together with Water Conservation and Water Demand Management (WC/WDM) are tools to improve water efficiency and reduce demands on freshwater resources. Non-conventional waters in many instances are used in conjunction with water conservation practices and technologies. By implementing these methods and processes, there is the added benefit of reducing waste discharge to water resources and thereby improving water quality within the catchment.

The key sources of non-conventional water include rain water, groundwater (brackish, sodic and sweet), waste water (domestic and industrial), mine water and seawater. For the purpose of this report and application in the Olifants catchment, seawater has not been considered because of the long distance which such water will have to be transported and associated high cost thereof. The role these sources of water play within the water cycle are illustrated in **Figure B2**. Like conventional water, non-conventional waters are both impacted, e.g. health and environmental impacts. These impacts are discussed in this report.

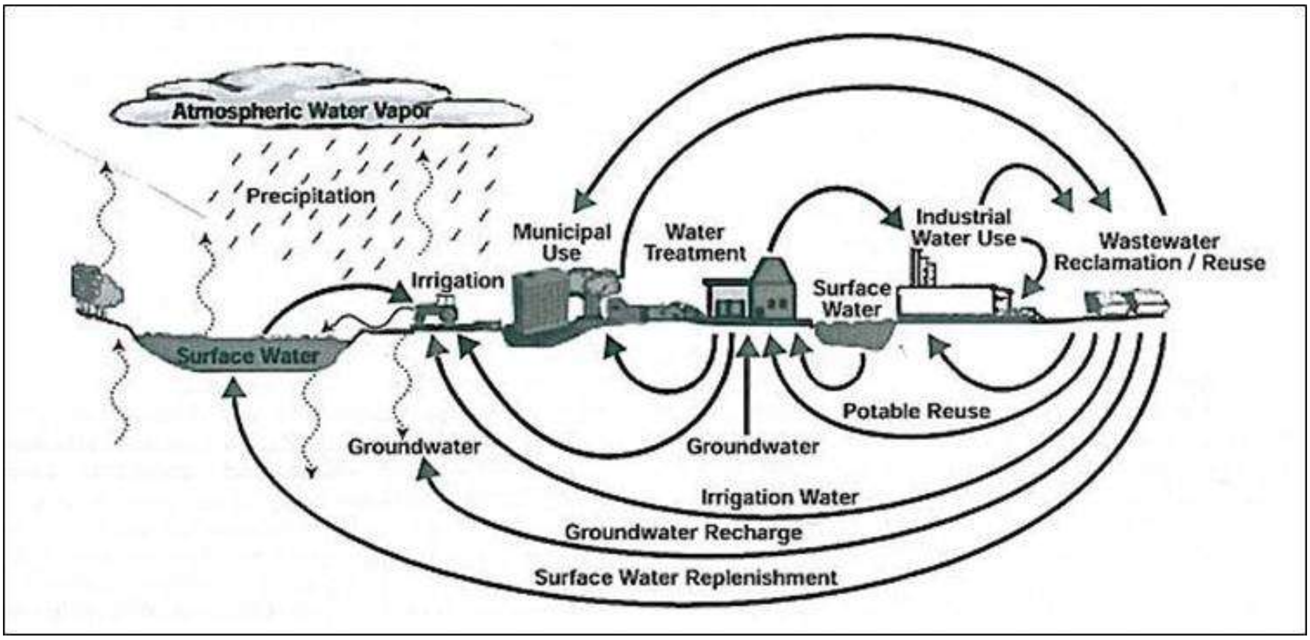


Figure B2: The role of engineered treatment, reclamation, and reuse facilities in the multiple uses on non-conventional water through the hydrological cycle. (Source: Asano, 1995)

Acid Mine Drainage (AMD) is the number one environmental problem facing the mining industry, and together with industrial wastewater, the biggest environmental problem in the Olifants Catchment. **Figure B2** illustrates the mining effects on drainage.

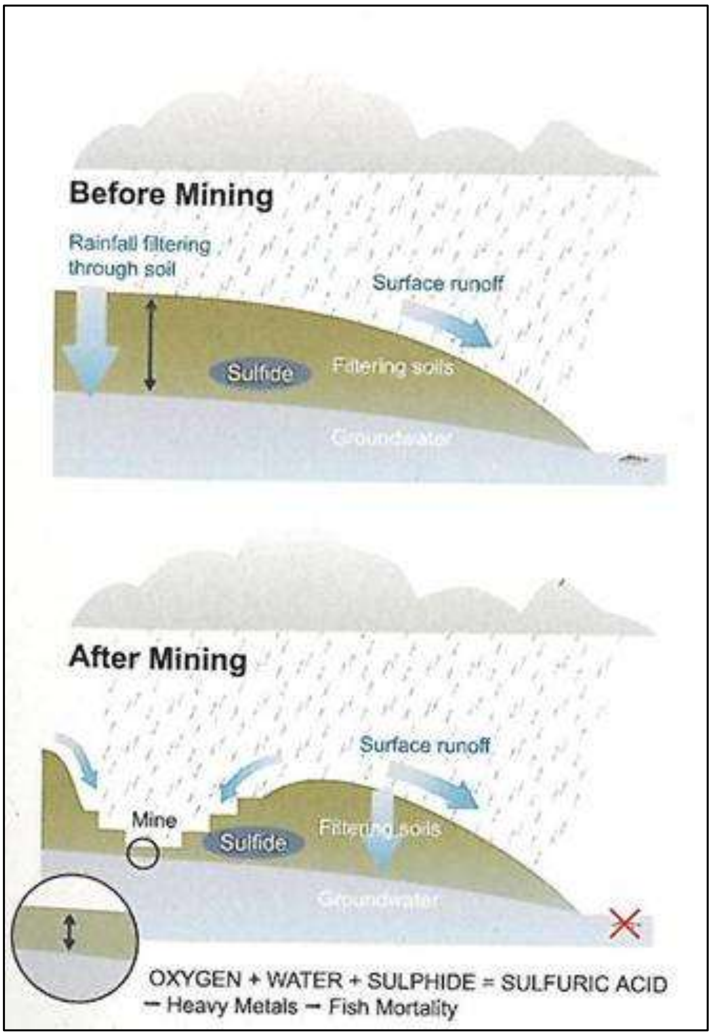


Figure B3: Mining effects on drainage. (Source: UNEP, 2004)

CURRENT EXTENT OF REUSED WATER IN THE STUDY AREA

While rainfall indirectly contributes to water supply, i.e. collects in rivers and dams from which abstraction then takes place, rainwater harvesting and enhancement can be an attractive alternative solution to water availability shortages. In particular, rainwater harvesting through its decentralised nature, enables people at household and community level to manage their own water.

There are a number of water users in the study area that already reuse water in the form of domestic waste water reused for process water or for irrigation, as listed in **Table B1**.

Table B1: Water users reusing domestic waste water

Company Name	Volume (Mℓ/day)	Type	Use
Bethal WWTW	13.70	N/A	N/A
Middelburg Mine Services	2.74	N/A	N/A
Middelburg WWTW	2.74	N/A	N/A
Steve Tshwete Local Municipality	20	Reuse	Industrial
Columbus Stainless Pty Ltd	2	Reuse	Process water make-up
Govan Mbeki Local Municipality	7.25	Reuse	Irrigation
Thaba Chweu Local Municipality	8	Reuse	Mine water (70%)
Witbank Prison WWTW	2.74	N/A	N/A

There are a number of water users that reuse their industrial waste water as shown in **Table B2**.

Table B2: Water users reusing industrial waste water

Company Name	Volume (Mℓ/day)	Type	Use
Eskom	Not available	Recycle	Process water
Anglo Platinum	69.32	Recycle & Reuse	Process water
Columbus Stainless Pty Ltd	5	Recycle & Reuse	Process water
Phalaborwa Mining Company	130	Reuse	Ore process water
SAB Miller	Not available	Recycle & Reuse	Process water

Apart from those listed above, Acid Mine Drainage is reclaimed in the Middelburg and Emalahleni areas and used for domestic and process water.

POTENTIAL FOR REUSE OF WATER AND THE USE OF MARGINAL WATER IN THE STUDY AREA

Further potential areas for sources of and use of non-conventional waters were identified:

- Rainfall Enhancement

  Cloud seeding is most effective in mountainous regions. The Drakensberg escarpment runs through the Lower Olifants catchment and provides suitable opportunity for cloud seeding to be implemented. This area is already a high rainfall area. In order to have longer lasting benefits from rainfall enhancement, a storage scheme for this area would be necessary.

- Rain Water Harvesting

  In South Africa, disadvantaged families in rural and urban areas (if located on big enough stands) can reduce their poverty situation through subsistence gardening in their stands. Harvested rainwater can be used for domestic use and to irrigate vegetable crops and offer an opportunity for a household to save on food expenditure and in so doing, to release cash for other needs. According to Mwege Kahinda, et al, (2008), rainwater harvesting is suitable in areas with rainfall from 200 mm to 1 000 mm, deep soils (0.2 – 0.3 m) and slopes less than 3%. Rainfall across the catchment falls within these limits.

- Groundwater

  There is extensive (registered not verified) use of groundwater within the Olifants Catchment. For the purposes of determining sources of non-conventional water, only groundwater with a TDS of 1 200 mg/ℓ or higher, which is called brackish groundwater, is considered. Water with a lower TDS is considered part of the conventional yield of the system.

Figure B4 illustrates the electrical conductivity of registered boreholes in the catchment. All purple, red and some yellow dots fall into the brackish water limit. Verification of these boreholes regarding their utilisation, sodium and chloride content and recharge rate will be required before considering the utilisation of the water.

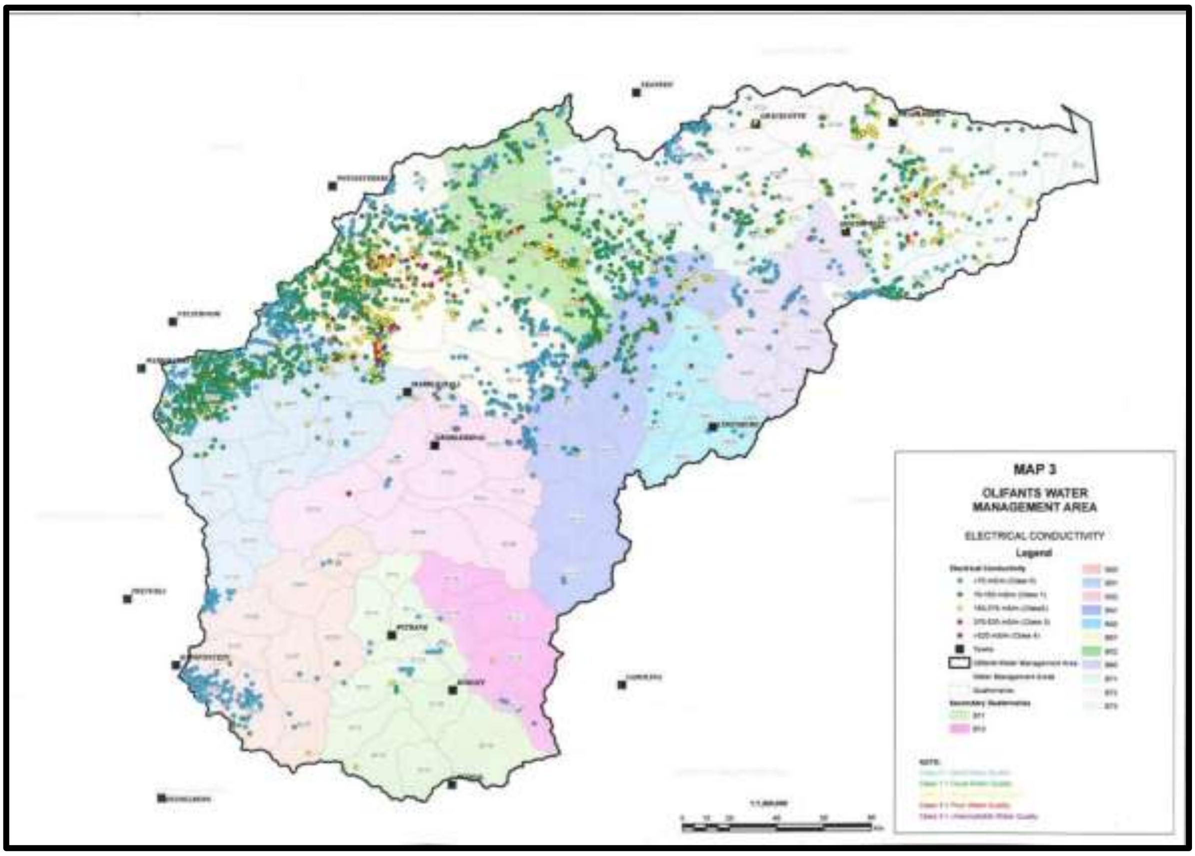


Figure B4: Electrical conductivity of registered boreholes in the catchment. (Source: Africon, 2007)

The sustainable availability of groundwater is dependent on the annual recharge from rainfall. In order to increase the yield of the groundwater system, improvements could be achieved through artifically recharging of the aquifers. Aquifers with a yield greater than or equal to 5 ℓ/s would be suitable for direct/artificial aquifer recharge applications. **Figure B5** illustrates aquifers with their potential utilisation of recharge, i.e. areas identified as Class 4 are aquifers not utilised to their full capacity, whereas areas identified as Class1 are over-utilised. The areas of Class 1 and 2 aquifers should be investigated further for direct / artificial recharge application in order to speed up recharge timeframes and thus reduce stress on the aquifer.

Applications for artificial groundwater recharge include utilising rainwater, reclaimed mine water, and treated waste water as source. The water quality of the water used for the artificial recharge would need to comply with DWA standards. The utilisation of artificial recharge to increase the yield and thus the higher utilisation of these Class 1 and 2 aquifers, must be considered carefully. The option of implementing the Godwinton Weir can recharge the dolomites close to the escarpment.

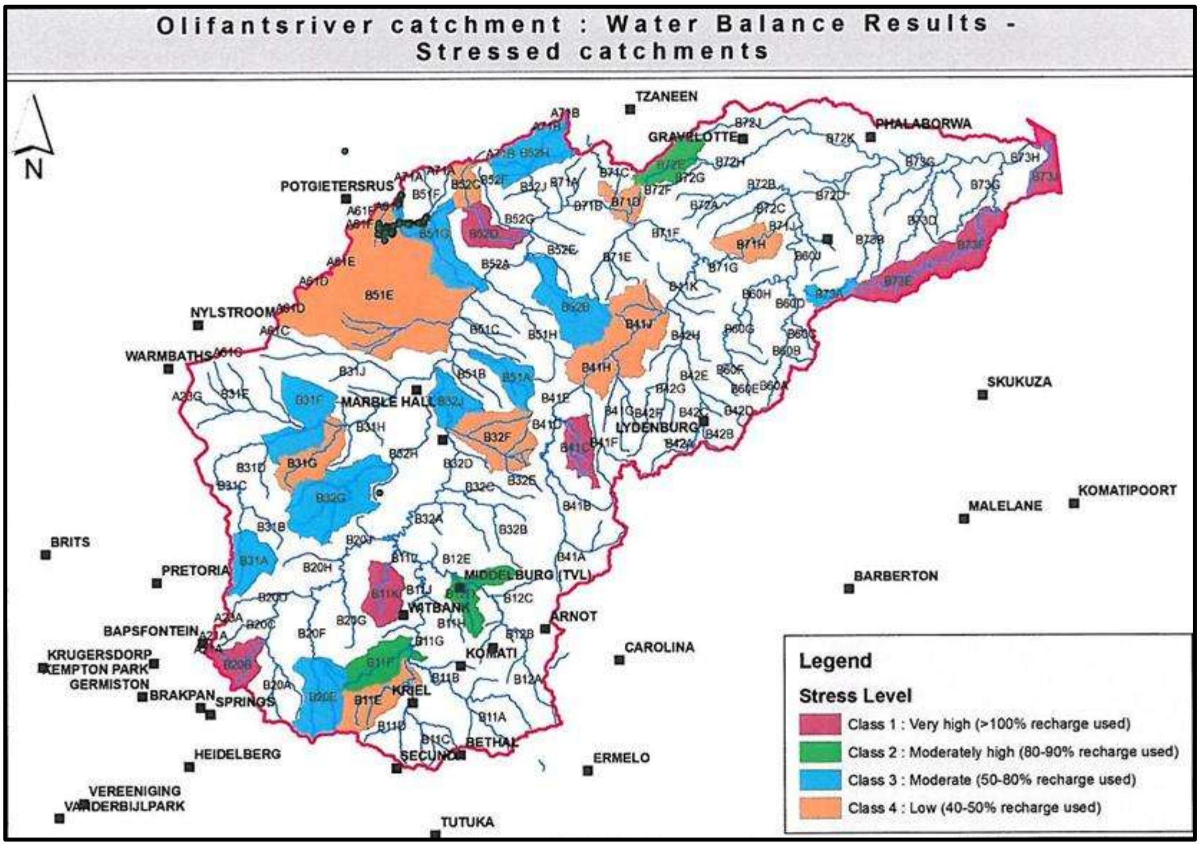


Figure B5: Map indicating stressed quaternary catchments. (Source: AGES, 2007)

- Waste Water

  Due to the scattered nature of the urban centres and the limited treatment offered by the waste water works, irrigation of crops is not feasible. Localised reuse of treated effluent for urban use, and the reclaiming of domestic effluent for the direct recharge of aquifers should be further investigated.

  Power stations in the catchment do not utilise water directly from the Olifants system, but rather water from adjacent catchments by means of inter-basin transfers. Implementation of water recycling technology at the plants will reduce their freshwater demand, and in turn, should reduce the inter-basin transfers, thus making more water available in those catchment systems. The potential savings at Eskom plants, using WC/WDM and water reuse technology, are shown in **Table B3**.

Table B3: Potential savings at Eskom plants using WC/WDM and water reuse technology

Power Station	Average water efficiency (2001-2006) (ℓ/use)	Potential Operational Savings (million m^3/a)	WC/WDM and Reuse Savings (million m^3/a)
Arnot	2.05	0.25	4.2
Duvha	1.99	0.00	6.3
Hendrina	2.30	2.37	5.2
Kriel	1.95	5.84	5.4
Matla	1.94	0.00	7.6
Kendal (dry-cooled)	0.11	0.84	n/a
	Total Savings	**9.3**	**28.7**

- Mine Water Reclamation

According to Anglo-Coal, the Emalahleni Coalfields produce excess water of 123 250 Mℓ per day (45 million m^3/a) at 97% recovery rate this equates to about 119 000 Mℓ/day. Currently 25 Mℓ/day (design capacity of the Emalahleni plant) of mine water is treated to potable standard and supplied to Emalahleni Municipality. This plant is to be expanded by a further 25 Mℓ/day. The nett additional yield to the catchment as provided by the existing plant is estimated to be approximately 5 million m^3/a. Although the abstraction and treatment is in excess of the 5 million m^3/a, this is due to a reduction in runoff that also takes place and reduces the yield.

A further 15 Mℓ/day plant (design capacity of the Optimum plant) has recently been commissioned to treat water from the Middelburg North Mine.

Four additional water reclamation plants have been identified by Anglo-Coal, as illustrated in **Figure B6**, to cater for the future expected decant of up to 45 million m^3/a in 2035. This additional yield could also be considered for new allocations such as for the expansion of operations of the platinum mines in the catchment downstream of the AMD treatment point(s). However, in the Integrated Water Resources Management Plan for the Olifants Catchment (2009), this additional water was earmarked for Emalahleni Municipality.

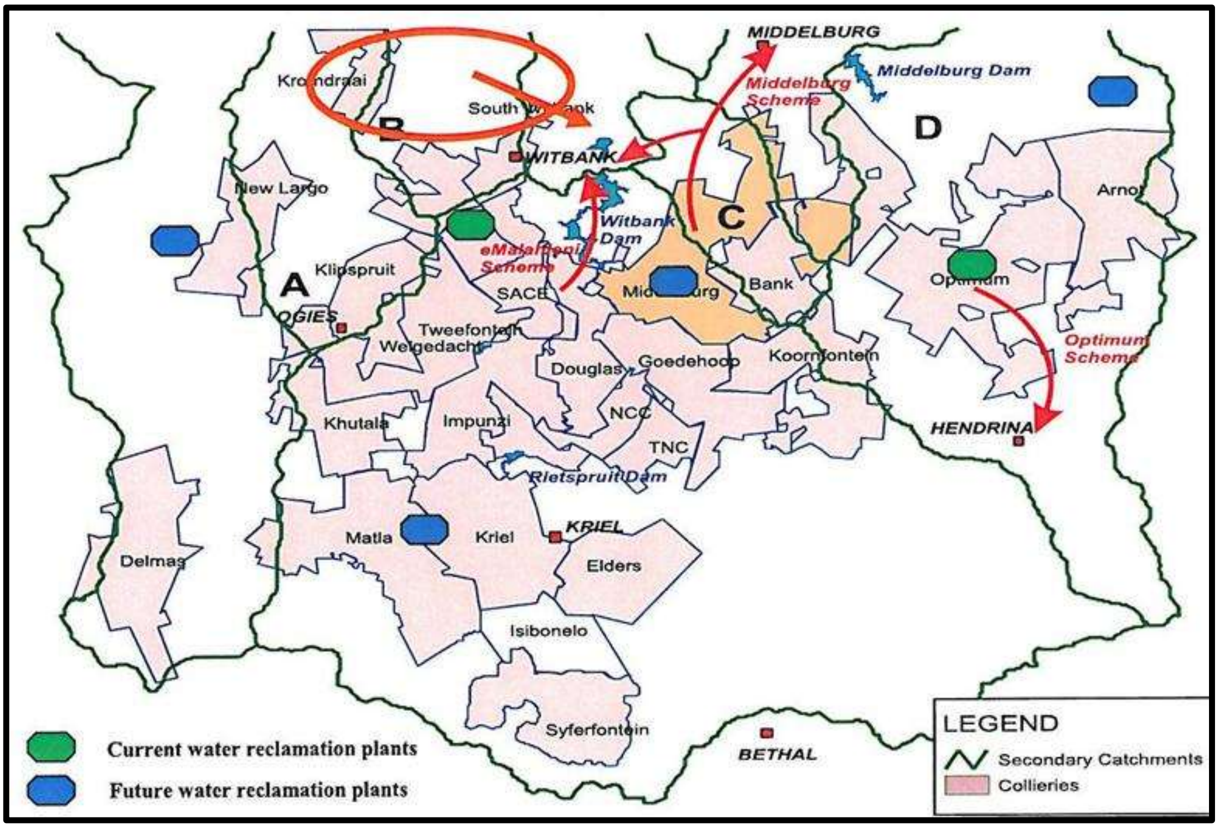


Figure B6: Locality map indicating current and proposed future water reclamation plants. (Source: Anglo-Coal)

Whether or not this water is additional yield or water that would have flowed down the river in any event is being widely debated. The groundwater specialists that carried out this work (Coleman, et al, 2011) are of the opinion that all new mine decants will be additional water and additional yield. The reason for the increase in MAR is the reduction in evapo-transpiration losses from soil moisture due to more rapid infiltration into underground storage in the mined areas.

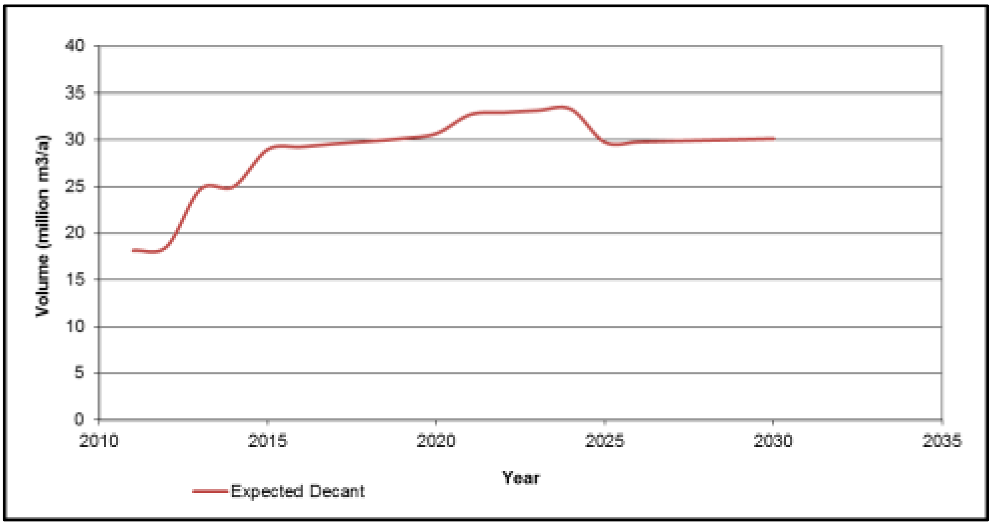


Figure B7: Decant water from coal mines in the Witbank catchment
Source: Golder Associates, 2011

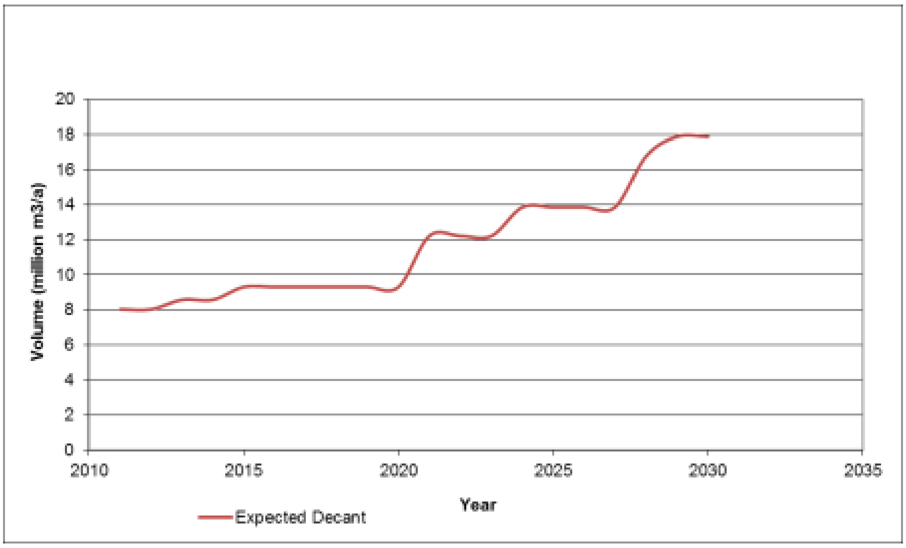


Figure B8: Decant water from coal mines in the Middelburg Dam Catchment
Source: Golder Associates, 2011

The current excess water decant in the catchments of Witbank and Middelburg Dams can be read off the graphs of **Figure B7** and **B8** as 18 million m^3/a and 8 million m^3/a respectively. It was assumed that the additional yield of 4.2 million m^3/a as a result of the Emalahleni Water Reclamation Plant and the Optimum plant comes from this excess water decant and that the rest (i.e. 21.8 million m^3/a) is part of the current system runoff in any event. The incremental future decant can then be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a, and of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a, in total over a period of 20 years.

Potential Impacts

The potential impacts, both positive and negative, that must be considered with the utilisation of non-conventional water sources, have been grouped into Management, Social, Health and Environment. There are, however, also impacts or implications of not utilising the non-conventional sources. With regard to the management related inputs it is concluded that the PPP route of managing AMD reclamation is the preferable option, and should receive maximum political support. Social impacts are more severe on the non-supply of water and the reuse of water is generally acceptable as long as it complies with health standards to ensure compliance to standards. With regard to health standards, there is adequate opportunity to use poorer quality ground water and reuse for irrigation. Care needs to be taken and monitoring systems should be in place to ensure proper management of processes. The reuse of water generally has a positive impact on the environment as it reduces fresh water demand and makes water available for the environment. Contamination of sources by untreated effluent should be avoided.

Possible Options for Reuse of Non-Conventional Water

The possible options for using non-conventional water in the Olifants River catchment are described briefly below.

- Option 1: Rainfall Enhancement
  The possible scheme involves cloud seeding in the escarpment region of the catchment. Cloud seeding is carried out by air dispersal (by plane) of condensation nuclei, in order to trigger cloud formation and increased storm events.

- Option 2: Rainwater Harvesting
  Rainwater harvesting provides immediate access to water by homesteads, especially those not located near to reticulation networks at basic level. The rainwater is collected from roofs and stored in tanks mainly for domestic use and production farming. Simple community built rainwater tanks provide the skills within the community to build and to carry out maintenance works on the tanks. It will also pass on the skills to neighbouring communities. Access to rainwater tanks is therefore unrestricted and not limited to qualifying for subsidy schemes.

- Option 3: Water Reclamation
  The Emalahleni Mine Water Reclamation Plant, a joint initiative between the mining houses such as Anglo Coal, BHP Billiton and Emalahleni Municipality treats mine water to potable standards to augment the domestic water supply. The plant currently produces 25 Mℓ/day of potable water at 97% recovery. Similarly, the Optimum plant near Middelburg produces 15 Mℓ per day. The treated mine water could be used for power generation, potable supply or aquifer recharge. The additional yield that can be achieved is 10 million m^3/a in the catchment of the Middelburg Dam and 12 million m^3/a in the Witbank Dam catchment.

- Option 4: Importing treated effluent from the East Rand
  There are several waste water treatment works in the Ekurhuleni municipal area in relative close proximity to the Olifants River Catchment. These WWTW's currently discharge their treated effluent into various tributaries of the Vaal River. It is possible to pump this water over the catchment divide into a tributary of the Upper Olifants to be reused by Eskom in power generation activities. The envisaged scheme involves the pumping of treated effluent from one WWTW to the next, with a central collection point at Daveyton (where a potential tertiary treatment process could be applied). From here, the effluent will be pumped over the divide to a point about 10 km north of Delmas.

Conclusions

The catchment is in a stressed situation. Numerous instances and examples of sources of non-conventional water in the Olifants catchment are dealt within in this report. Whilst the catchment is in a stressed situation, even the smaller contribution by some sources, need to be considered. Some can only make a difference to the position of local users, but it may not make a significant contribution towards creating a positive water balance in the total system.

The component that can make a significant difference to the water balance in the catchment and is to be considered as a major resource is the utilisation of the AMD in the Upper Olifants sub-catchment. It needs to be utilised more effectively.

RECOMMENDATIONS

The following actions are recommended:

- Proceed with the utilisation of AMD and implementation of further AMD initiatives as indicated in this and the other reports of this series.
- Promote the utilisation of PPP's for the utilisation of AMD in order to unlock the required investment and operational management capacity of industry.
- Develop a clear policy, strategy and guidelines for the use and application of all components of non-conventional waters.
- Legislative and implementation tools for the regulating and implementing the use of marginal waters should be established and made available. This should cover aspects such as: water reuse and recycling, implementation of water efficient technology in different industrial sectors, improving water efficiency, etc.
- The Water Conservation and Water Demand Management initiatives identified in the DWA Report "The Development of a Comprehensive Water Conservation and Water Demand Management Strategy and Business Plan for the Olifants and Inkomati WMA's. Industrial component: Power Generation. Situation Assessment", (Prepared by VWG Consulting on behalf of the Directorate: Water Use Efficiency) – should be considered for implementation.
- Rainwater harvesting in the catchment should be promoted and expanded. The subsidy for households for rainwater tanks in the rural areas should be continued and expanded. The use of such harvesting in cities should be promoted and can be even made compulsory for any new town development.
- Opportunities for groundwater recharge should be considered and the approach generally promoted. The feasibility of the implementation of the Godwinton weir to recharge the dolomite aquifer on the escarpment should be investigated further.
- The application of water recycling and internal reuse in industrial process should be continuously be required, promoted, advanced and implemented.
- The possible future implementation of rainfall enhancement should be taken further with a specific project to take the existing research knowledge to the next level and prepare it for possible future implementation.
- The transfer into the catchment of sewage from the Vaal River catchment for reuse in the Olifants catchment need to be considered in conjunction with the strategic constraints of water requirements in the Vaal River catchment itself.

ANNEXURE C:

POSSIBLE WATER CONSERVATION AND DEMAND MANAGEMENT MEASURES

The Olifants River catchment is currently one of South Africa's most stressed catchments as far as water quantity and water quality is concerned. The main purpose of this study is to develop reconciliation strategies to resolve this water stressed situation, both in the short and long term. The strategies do not necessarily entail the augmentation of the water resource. Experience has shown that often the most cost effective option is to reduce the water demand, especially if the existing water use is inefficient.

The purpose of this report is to report on water use efficiency within the study area and suggest likely savings that can be made based on experience from other water conservation and demand management initiatives. This analysis of water use efficiency considers several water use sectors separately since each sector has its own characteristic or benchmark efficiency which should be achievable. The sectors considered in this report are:

- Urban,
- Rural,
- Irrigation,
- Mining,
- Industrial, and
- Power generation.

The urban sector is generally inefficient with its water use, with unaccounted for water use in Emalahleni being especially high. Of concern is the lack of reliable information of the water use efficiency in Polokwane.

Rural water use within the context of this report refers to water supply areas where there is a low level of service and often no, or limited payment for services. This is typical of rural areas where basic services are free. Although these schemes are not necessarily using water efficiently there is little scope for saving due to the low level of service.

The largest water user sector in the Olifants River catchment is by far the irrigation sector. Due to rapidly increasing pumping costs it is suggested that irrigators can no longer afford to be inefficient and that irrigators within the Olifants are becoming increasingly efficient with their water use. Nevertheless, there is still widespread use of irrigation techniques that are less than optimal and replacing sprinklers with drip irrigation could result in significant savings. However, in the past there has not been much success in saving water through WC/WDM in the irrigation sector because any water saved by irrigators through improved efficiency is used to expand the irrigated area. It is suggested in this report that real savings can be achieved through one of two mechanisms:

- Trading of the saved water to other water use sectors. This would require willing sellers and willing buyers.
- Compulsory licencing to reduce allocations by the amount of water saved.

The mining sector is already very efficient with its water use due to the very high value that mines (specifically the platinum mines) place on their water. However, the mining sector has indicated that technology is available to reduce their demands by up to 10% through improved recycling techniques. A possible area for reducing water allocations to the mining sector is to evaluate the water use by the coal mines. There is an estimated allocation of 20 million m^3/annum to coal mines in the Upper Olifants, but as coal mines develop they generate surplus water. It seems likely that the original allocations are in most cases no longer required and a significant amount of water could be saved by withdrawing these allocations, either through compulsory licensing or by non-renewal when the licence expires. This would need to be done in close consultation with the coal mining sector.

The water use by the industrial sector within the study area is relatively small and hence the scope for water savings from this sector is very limited.

The second largest user of water in the study area is power generation and while their water use is efficient, there is nevertheless scope for improved efficiency and water savings. These savings would however necessitate very costly water reclamation works. It is also debatable whether water saved by the power generation activities within the study area would be reallocated to users in the Olifants River catchment, or be seen as a saving from the water source, which in this case are the Komati and Vaal river catchments.

The table below provides a summary of the estimated maximum reduction in water demand that could be achieved per water use sector.

Table C1: Summary of possible water savings

Sector	Current water requirement (million m^3/a)	Estimated saving (million m^3/a)	Comment
Urban	140.4	32.1	Achievable
Rural	29	0	Problematic due to existing low levels of service
Irrigation • Improved irrigation systems • Improved conveyances	486	 19 16	Requires willing buyer/willing seller Very costly
Power generation	228	27.3	Very costly to Eskom
Mining	86	5	
Industrial	9.0	~0	
Total	**978.4**	**99.4**	

ANNEXURE D:
WATER REQUIREMENTS AND WATER RESOURCES

The Olifants River catchment is currently one of South Africa's most stressed catchments as far as water quantity and water quality is concerned. The water requirements in the Olifants Water Management Area (WMA) have increased substantially over the last few years due to diverse activities e.g. power generation, mining, urban development, improved service delivery to rural communities, and irrigation. The potential future demand for water from the mining sector as well as rural communities is especially large and this lead to the construction of the De Hoop Dam, which will be completed in 2012. However, concerns were raised that even with the additional yield provided by the De Hoop Dam and the raised Flag Boshielo Dam, the water demands would soon outstrip the available resource. This prompted this study to develop reconciliation strategies to alleviate the current water deficits and to ensure a sustainable water supply for the next 25 years.

Reconciliation strategies entail firstly identifying an envelope of likely future water demands, determining the available water resource, then identifying possible interventions to reconcile the water demand with the available water resource into the future. The purpose of this report is to document the current and future water requirements, the water resource, and hence the current and future water balance.

The report has been structured to disseminate the information as three sub-catchments, namely the Upper, Middle, and Lower Olifants with the water demands of the Mokopane and Polokwane areas being grouped with the Middle Olifants. Within each sub-catchment, water requirements are documented for each user sector, which are Urban, Rural, Industrial, Mining, Irrigation and Power Generation. The water resource within each sub-catchment has been estimated as the yields from major dams and the resources from diffuse sources such as run-of-river abstraction, farm dams and ground water. Current water balances are presented in tabular form while future water balances are presented graphically. All water balances are before taking the ecological Reserve into account. This aspect is dealt with in a separate report.

The results of this Water Requirements and Water Resources report are summarised in the **Table D1** and **Figure D1** below while **Figures D2, D3 and D4** show the balances in the three sub-catchments, Upper, Middle and Lower Olifants.

Table D1: Current water balance of the Olifants River Catchment (million m^3/a)
Current Water Balance (units: million m^3/annum)

Sub-catchment	Water requirement	Water resource	Losses	Comp. Release	Water Balance
Upper	609	630	0		21
Middle	187	185	0	(19)	(21)
Lower	220	248	(5)		23
Total	1016	1063	(5)	(19)	23

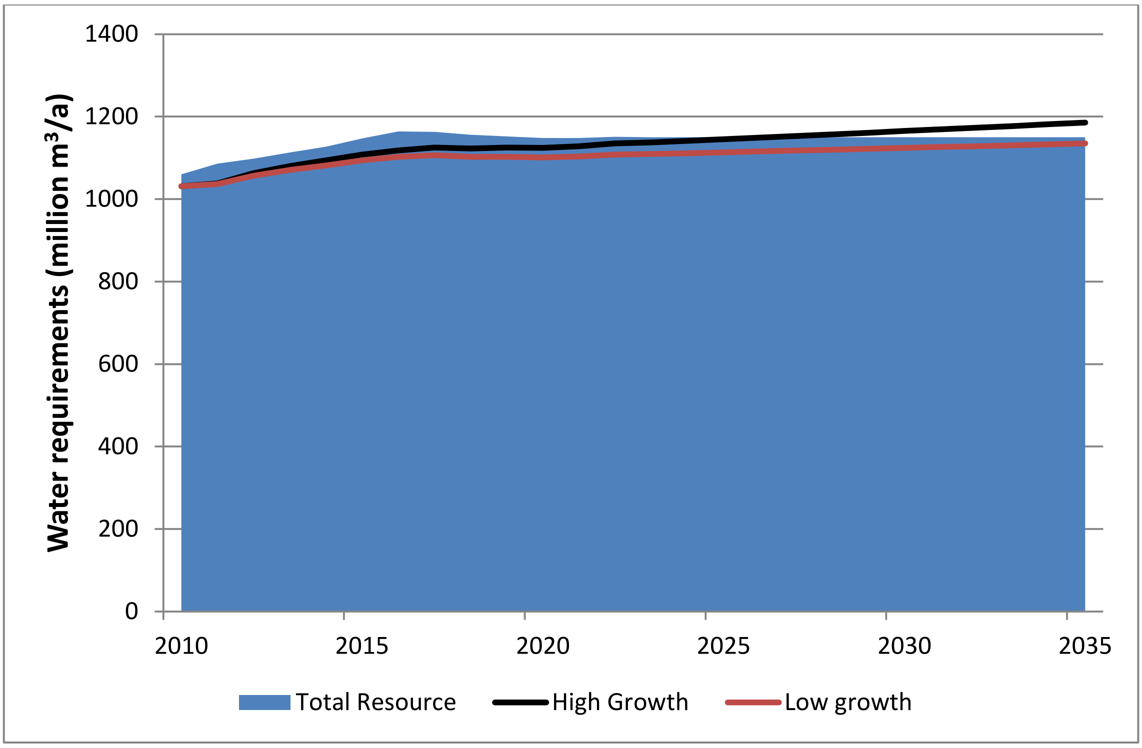


Figure D1: Future water resource and water requirements in the Olifants River Catchment

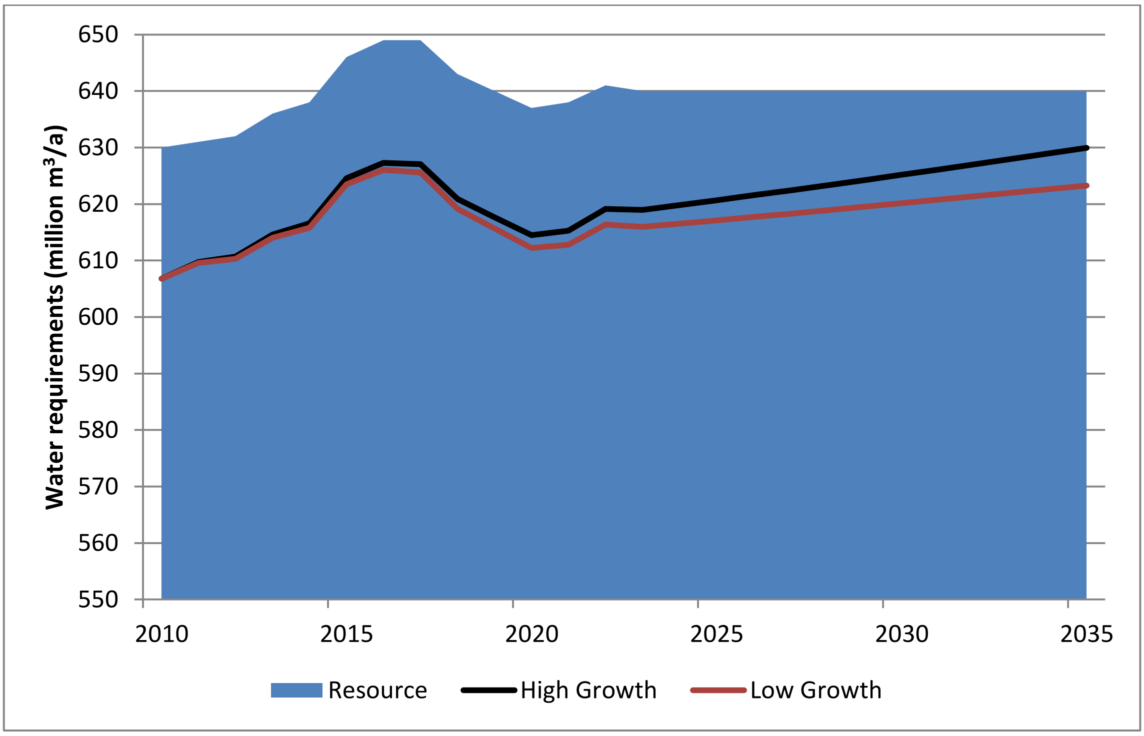


Figure D2: Future water resource and water requirements in the Upper Olifants River Catchment

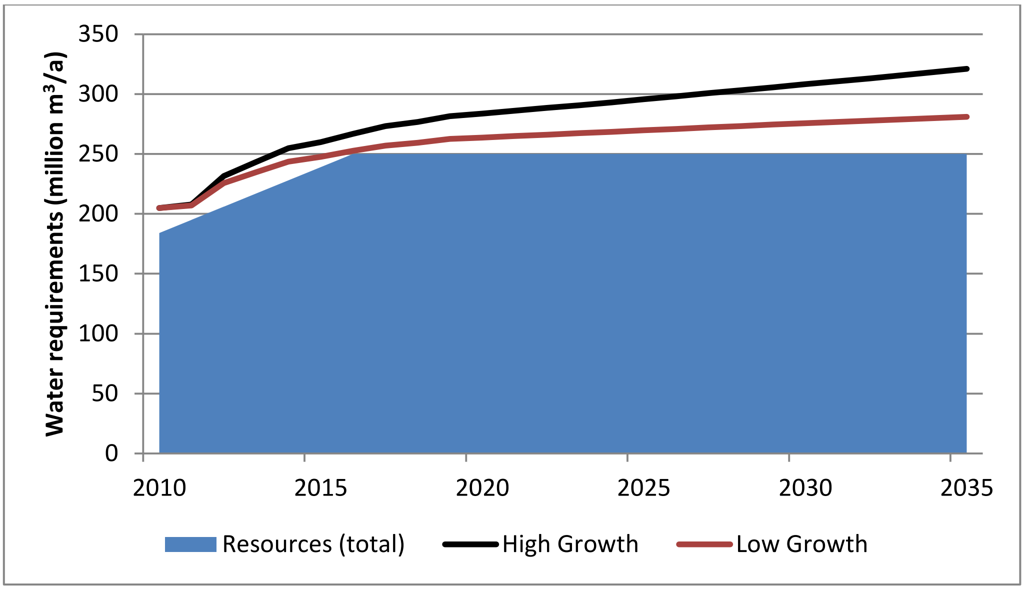


Figure D3: Future water resource and water requirements in the Middle Olifants River Catchment

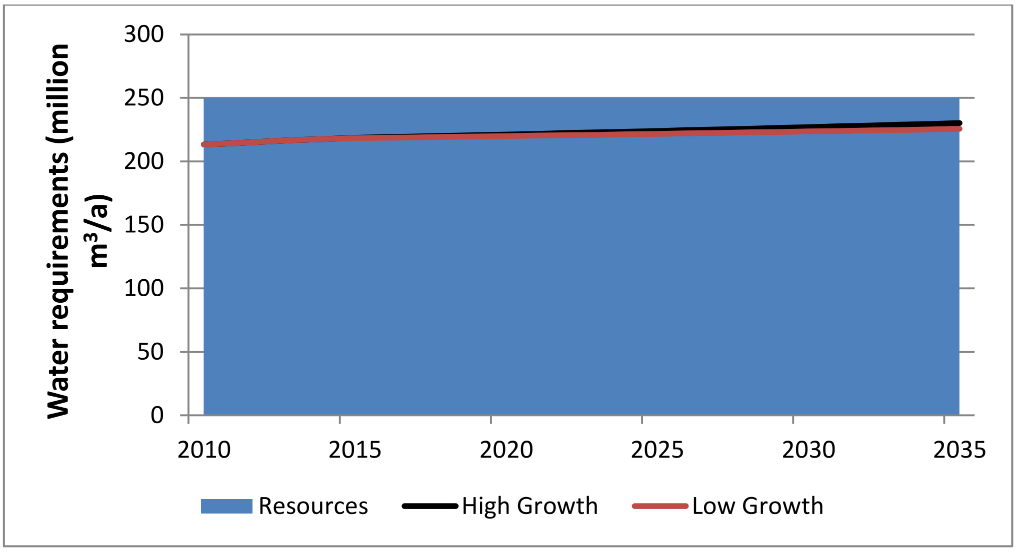


Figure D4: Future water resource and water requirements in the Lower Olifants River Catchment

While the water requirements and water resources presented in this report are based on the latest information available, derived from numerous recent hydrological and water resources studies as well as new information that has been sourced during the course of this study, the following uncertainties are noted:

- Water use by irrigators not located within irrigation boards.
- Losses
- Water use by the coal mining sector in the Upper Olifants river catchment.

ANNEXURE E:
WATER QUALITY

The purpose of this report is to document the outcomes of the Water Quality Assessment Task, Review of Water Quality of Surface Water Resources for the Development of a Reconciliation Strategy for the Olifants River System. This report is an assessment of the water quality situation in the Olifants River System in relationship to the land uses, activities, population, natural features, institutional arrangements, water quantity of the catchment and any other negative or positive impacts that will influence the water quality status.

The report focuses on the current water quality, but uses historical data to highlight “stresses” on the current water quality which illustrates whether there is deterioration or improvement of the water quality of the surface water in the Olifants River System

The upper part of the Olifants River catchment forms part of the Highveld and is composed of undulating plains and pans, and a large open flat area, referred to as the Springbok Flats. These areas are divided from the Lowveld by the escarpment, which consists of various hills and mountain terrain. The Lowveld consists mainly of plains and undulating plains. The catchment contains three basic rock types which are sedimentary, igneous and metamorphic. The most important economic potential lies in the mining of granite and gneiss for use as polished stone and the occurrence of gold, platinum and other minerals in the greenstone lavas.

There is significant mining, predominantly for coal, and other industrial activities around the Wilge, Bronkhorstspruit, Klein Olifants and Olifants Rivers, which are the main contributors to poor in-stream and riparian habitat conditions where acid leachate from mines is a primary contributor to poor water quality and instream conditions. Other water uses include domestic, livestock watering and, power generation.

Water quality is determined by the activities on the catchment, the land use and the geology. Water quality guidelines published by the Department as well as the water quality reserve were used to develop combined guidelines for the study area based on Domestic, Agriculture and Aquatic Ecosystem water guidelines.

The water quality in the study area is generally suitable for the intended use, although there are some exceptions. The Middelburg Dam (station B1H004) is under pressure as reflected by the pH, levels of ammonia as well as nitrite/nitrate levels. The low pH levels may be due to acid rain as a result of mining activities in the study area. The high levels of ammonia and nitrate/nitrite levels may be due to use of fertilisers and is an important indicator of faecal pollution as a result of poor sewage treatment (WHO, 1996). The phosphates are slightly high throughout the study area, but within the acceptable range. This may be due to improper use of fertilisers as well as discharge of sewage into water sources. Although the hlorides are generally within the ideal range, trend analyses show that they are on an upward trend. This may be due to the various mining activities in the area.

The sulphate levels range between ideal and unacceptable with some of stations showing sulphate levels within unacceptable ranges (stations B1H020, B1H019, B1H005 in the Witbank Dam Catchment, stations B1H012 in the Wilge River and Loskop Dam Catchment and station B3H002 in the Middle Olifants Catchment). The results also show an upward trend in sulphates for most stations except stations B1H019, BH017, BH021, BH002 and BH012. The high levels of sulphates may be due to use of ammonium sulphate fertilisers as well as mining activities in the area.

The EC values are also slightly high, but within acceptable and tolerable ranges. The trends analysis also shows EC as being in an upward trend for most of the stations. During the late 1990s there was a sudden increase in the electrical conductivity of the water in the Loskop Dam. This was maintained until 2005/2006, after which there has been a gradual reduction in electrical conductivity. This can possibly be related to the neutralisation of acid mine drainage water in the catchment, which was discontinued around 2005

Most of the dams in the Olifants River System are in a low trophic state, except for the Bronkohorstspruit Dam which is in a hypertrophic state. However, the Olifants River and the Loskop Dam are fast approaching eutrophic state. This may be due to the substantial sewage treatment plant return flow volumes in the Klipspruit, Witbank Dam and Witbank and Middelburg Dam to Loskop Dam catchments. The return flows contribute to the base flow into Loskop Dam and have been cited as a cause of eutrophication in the upper reaches of the Loskop Dam and the Klein Olifants River (DWA, 2004).

ANNEXURE F:
ENVIRONMENTAL SCREENING REPORT

The water requirements in the Olifants Water Management Area (WMA) and the adjacent areas of Polokwane and Mokopane, which are supplied from the Olifants, have increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

A reconciliation strategy, aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future, is required for the basin and its water users.

The environmental screening focused on the possible schemes considered in the strategy and aims to:

- summarise any key environmental or social issues that should be taken in account when considering and comparing options;
- identify any environmental or social “fatal flaws” or “red flags” associated with any of the projects; and
- identify environmental authorisations that will be required for any of the projects.

The assessment is based on available documented information, and no site visits, field work or additional data collections were undertaken to verify or update the available information. Implementation of the Reserve (surface water, groundwater and water quality aspects) during construction and operational phases is assumed to be a condition of any proposed scheme. It is assumed that this will ensure that the aquatic ecology and requirements for basic human needs are adequately provided for and protected.

The most well-known conservation area is the Kruger National Park (KNP) located in the Lower Olifants sub-area of the Olifants WMA. There are two centres of endemism within the Olifants WMA: namely the Sekhukhuneland, and Wolkberg Centres of Endemism. These areas contain high levels of diversity with many species restricted entirely to these areas. As such they are of high priority in terms of conservation. The high biodiversity and the many unique plant species restricted to these areas means that they are particularly vulnerable.

The following reconciliation options were considered during the study:

- Reconciliation options that can reduce water requirements
  - Eliminating unlawful water use
  - Water Conservation and Water Demand Management (WC/WDM) in the irrigation sector
  - WC/WDM in the domestic water use sector
  - WC/WDM in the mining sector
  - Reducing assurances of supply
  - Compulsory licensing
  - Water trading

- Reconciliation options that can increase water supply
    - Removal of invasive alien plants (IAPs)
    - Refinements to System operating rules
    - Rainfall enhancement through Cloud Seeding
    - Groundwater development
    - Water Transfers
        - Transferring treated effluent from the East Rand
        - Transferring more water from Vaal Dam
        - Water transfer from the Crocodile (West) River System
    - Dam Options
        - Raising of the Blyderivierspoort Dam
        - New dam downstream of Rooipoort
        - New dam on the farm Godwinton in the Olifants River Gorge
        - New dam on the farm Chedle in the Olifants River Gorge
        - New dam on the farm Epsom in the Lower Olifants River
        - New dam on the farm Mica in the Lower Olifants River
        - New dam on the farm Madrid in the Lower Olifants River
    - Utilising the acid mine drainage (AMD) in the Upper Olifants
    - Desalination and transfer of seawater

The strategy recommends the following options for implementation:

- Water Conservation and Water Demand Management in all sectors;
- Reducing unlawful water use;
- Removal of Invasive Alien Plants;
- Development of Groundwater Schemes; and
- Treatment of decanting water from the coal mines in the Witbank Dam and Middelburg Dam Catchments.

A water balance is achieved with the selected reconciliation options applied.

The Strategy encourages groundwater development in unstressed aquifers and the investigation of a regional water scheme with the Malmani dolomites as resource is recommended. Potential impacts on adjacent groundwater using landowners, surface flow and riverine ecology and groundwater dependent ecosystems could potentially be affected by groundwater development if it is not implemented sustainably.

The construction of bulk water supply infrastructure such as dams and pipelines with require environmental authorisation for which an environmental impact assessment process that includes a public participation process will have to be undertaken.

Any water transfers into the catchment will impact on the receiving streams due to an increase the flow and loss of natural variability will consequent ecological affects. Organisms from the donor catchment may also inevitably be transferred with the water.

The use of treated acid mine drainage can increase the system yield and improve the water quality. No significant impacts are expected.

Transferring treated effluent from the East Rand will require right of access and aquaduct servitudes and may result in water quality problems.

Transferring additional water from the Vaal Dam will also require servitudes for a pipeline and application of the Vaal River tariff will result in a high water price.

The raising of the Blyderivierspoort Dam or construction of any of the possible five new large dams identified will have potentially significant social and ecological impacts which will require a full environmental and social impact assessment and to which the hierarchy of mitigation measures (enhance, avoid, reduce, restore compensate, offset) will have to be applied.

Rainfall enhancement could increase the size and frequency of floods.

The increase on utilisable yield from removal the invasive alien vegetation is expected to be negligible, but this option will have a positive impact on biodiversity.

No fatal flaws have been identified for any of the options considered. The construction of large dams is expected to have the greatest ecological and social impacts.

ANNEXURE G:
PRELIMINARY RECONCILIATION STRATEGY

The water requirements in the Olifants Water Management Area (WMA) and adjacent supply areas of Polokwane and Mokopane, have increased substantially over the last number of years due to increases in a range of activities including power generation, mining, the steel industry, urban development and agriculture. The mining industry in particular has grown significantly.

Figure G1 shows the Study Area. The Olifants Catchment has been divided into three management zones, namely the Upper, Middle and Lower Olifants Management zones which are also shown on the map.

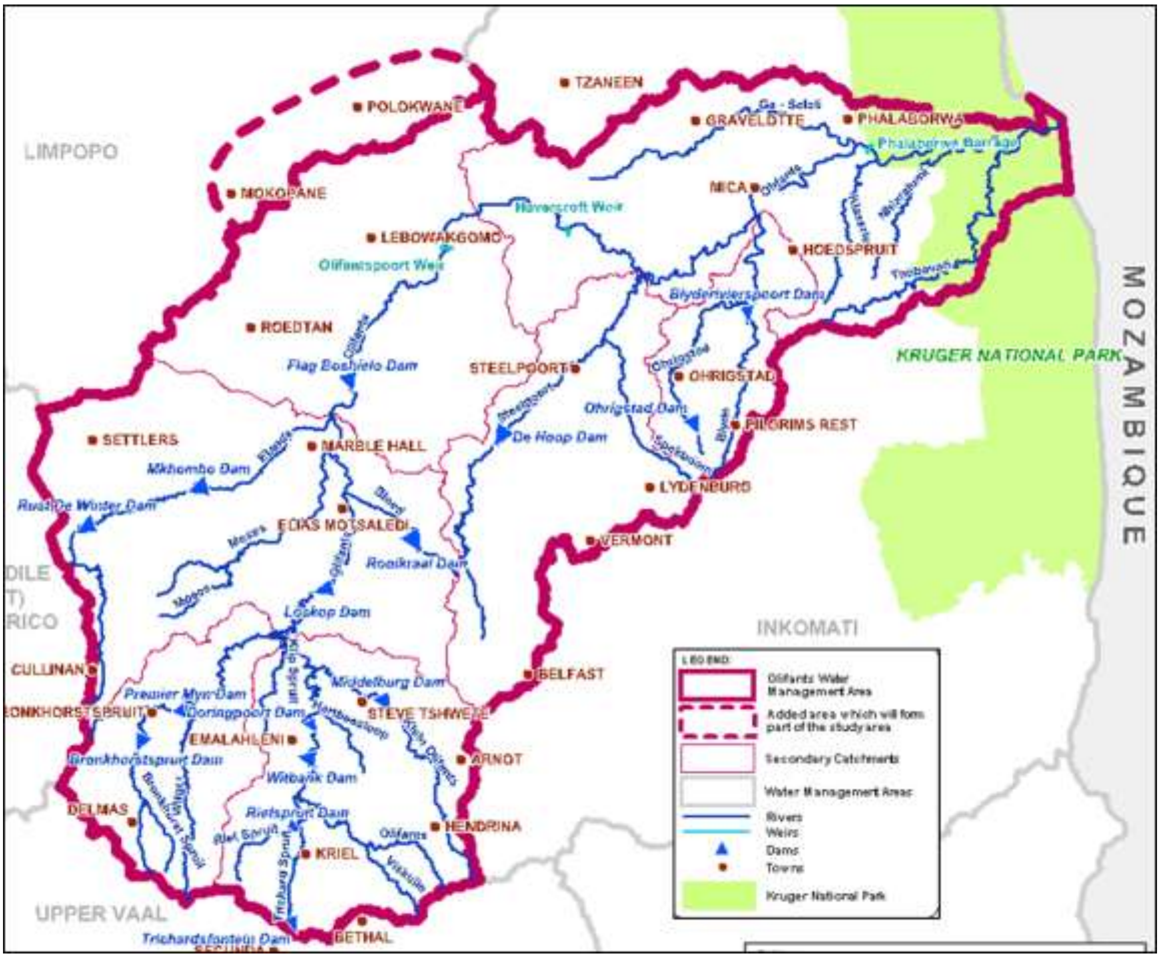


Figure G1: The Study Area

The Olifants River catchment is currently one of South Africa's most stressed catchments as far as water quantity and water quality is concerned.

The study area requires a reconciliation strategy aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future.

The main output of this study will be a Final Reconciliation Strategy for achieving a balance between the requirements for water to support livelihoods and economic development, the available resource, and the conservation of the environment to sustain its functions for future generations. The use of the water resource should be founded on the three principles of equity, sustainability and economic efficiency.

As a result of the highly stressed condition of the study area and the fact that it will take a substantial period of time to develop the final reconciliation strategy, a first order or preliminary reconciliation strategy was required.

The following are regarded as objectives for the preliminary reconciliation strategy:

- To provide an understanding of the surface and groundwater situation in the area of the Olifants River Supply System, in terms of water quantity and water quality.
- To describe the possible interventions that can address the current and projected future water resource deficiencies and water quality problems.
- To sequence these interventions and indicate which of these interventions will yield early benefits.
- To pave the way for the Final Reconciliation Strategy.

This report represents the Preliminary Reconciliation Strategy.

THE RESERVE

The Reserve is that portion of the natural run-off that must be available in the river in order to sustain the aquatic ecology, and also to provide water for basic human needs (BHN). This is required by sections 16, 17 and 18 of the National Water Act (Act 36 of 1998) (NWA). The Reserve is not a steady flow, but a variable flow that mimics natural variation in flows in the river. The quantity that is required takes into account ‘normal’ conditions, as well as drought conditions.

The BHN component of the Reserve has been catered for in the total water requirements for domestic water use and the focus of the description below is entirely on the ecological component of the Reserve

The Olifants River Comprehensive Reserve Study was undertaken during 1999 and was only the second Comprehensive Reserve Study undertaken in South Africa.

Present Ecological State (PES 2010) and the Ecological Categories (ECs) were determined and compared with the 1999 EcoStatus and ECs. The Recommended Ecological Category (REC) at each site was then reviewed.

There were not many changes in the PES or REC from the 1999 study to 2010. In the upper part of the catchment, the REC has reduced from a C to a D, while in the lower part of the catchment; it has increased from a C to a B. This study did not recalculate the Ecological Water Requirements (EWRs) themselves, and only reconfirmed the ecological status of the catchment. The associated flows and rule tables are therefore the same as those developed in 1999.

A change from Category C to Category B in the lower part of the river may have a significant impact on the EWRs for that part of the river. However, since the EWR for the site just upstream of the Kruger National Park (KNP) was previously assessed as a Category B, and has remained so, the overall effect on the availability of water for beneficial use will probably be small. This will be confirmed later on in the study.

WATER RESOURCE AVAILABILITY

- **Groundwater**

  The availability of groundwater resources for abstraction is controlled by the aquifer characteristics of permeability and storage. The aquifers in the Olifants River Catchment can be divided into three main types namely, intergranular and fractured, fractured and karst, or only fractured [GMKS, Tlou and Matji and Wates, Meiring and Barnard, 2004]. The highest yields are available in the fractured karst (dolomite) aquifer yielding 0,1 – 50 ℓ/s. Favourable resources are also available in the deep weathered Karoo basalt and valley areas underlain by norite and gabbro of the Bushveld Igneous Complex and yielding up to 5 ℓ/s. Low yields can be expected in the Karoo siltstone, shale and mudstones, the Nebo granite, as well as the Waterberg sandstone and quartzite - with yields in the order of 0,5 ℓ/s.

  The Groundwater Yield Model indicated that there is a surplus of groundwater available in the order of at least 70 million m^3/annum, which can be developed for community water supply (SATAC Joint Venture, 2008).

  Groundwater is currently being over-utilised in certain areas of the Olifants Catchment, e.g. in the Delmas / Bapsfontein area where too much water is abstracted from the dolomitic aquifer. This has resulted in an increase in the number of sinkholes in that area over the last decade.

  There are therefore some areas of good yield and some really problematic over-abstractions that MUST be addressed.

- **Surface Water**

  - **Yield of Large Dams**

  The surface water resources of the Olifants River are already well developed, especially the upper reaches, with several large dams constructed to supply water to large irrigation schemes as well as to domestic and industrial water users. The significant dams with their historical firm yields and 1:50 year yields are listed in **Table G1**.

Table G1: Large Dams in the Olifants River Catchment

Dam	Location		Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
	Management Zone	Quaternary Catchment			
Bronkhorstspruit	Upper	B20C	58.9	16.9	23.5
Middelburg	Upper	B12C	48.4	12.6	14.0
Witbank	Upper	B11G	104.0	29.5	33.0
Loskop	Upper	B32A	374.3	161	168
Rust de Winter	Upper	B31C	27.3	9.8	11.7
Mkombo with Weltevreden weir	Upper	B31F	205.8	11.7	11.7
Flag Boshielo	Middle	B51B	178.8	53.0	56.0
De Hoop (under construction)	Middle	B41H	347.4	98.0	99.0
Ohrigstad	Lower	B60E	13.2	18.9	19.8
Blyderivierpoort	Lower	B60D	54.6	110	130

Note: Yields are before any allowances are made for the environmental water requirements

– **Diffuse Water Resources**

In addition to the yield of the major dams listed in Table G1, there are a large number of farm dams in the Olifants River catchment that contribute to the yield of the system. There are also many water users, mostly irrigators that abstract water directly from the river, with these run-of-river sources also forming part of the water resource. The yield related to farm dams and run-of-river abstractions (referred to further as diffuse sources) are much more difficult to quantify than the yields of large dams. The approach taken in this study was to quantify the actual water supplied from farm dams and run-of-river through the use of a water resources model and to equate the resource to the modelled supply. The diffuse water use is therefore in balance with the diffuse water resources.

– **Transfers In**

There are several large water transfers from the Upper Komati and the Vaal Systems into the Upper Olifants River catchment to supply the six power stations located in the Upper Olifants catchment. These water transfers approximate 228 million m^3/annum. The transfers are fully utilised in meeting the requirements of the power stations so the effect on the water balance in the catchment is zero. There are also three small transfers into the Middle and Lower Olifants from the Letaba / Levhuvhu WMA.

The total surface water resource of the Olifants River catchment is summarised in **Table G2**.

Table G2: Summary of Total Current (2010) Water Resources within the Olifants River Catchment (Units: million m^3/a)

Management Zone	Yield from Major Dams (1 in 50 year)	Yield from Farm Dams and Diffuse Sources	Transfers In	Total
Upper Olifants	262	128	228	**618**
Middle Olifants	56	71	1	**128**
Lower Olifants	150	49	3	**202**
Total	**468**	**248**	**232**	**948**

Note: *De Hoop Dam is excluded*

Current and Projected Water Requirements

- **Current**

The water user sectors in the study area are Domestic/Industrial, Mining, Agriculture, Irrigation, Power Generation and Forestry. The water requirements of these sectors are summarised in
Table G3.

Table G3: Current Water Requirements (2010) (All units in million m^3/a)

Management Zone	Domestic / Industrial	Mining	Irrigation[1] (Adjusted to 98% assurance of supply)	Power Generation	Total
Upper Olifants	109	21	254	228	**612**
Middle Olifants	39	24	93	-	**156**
Lower Olifants	21	36	161	-	**218**
Total	**169**	**81**	**508**	**228**	**986**

Notes: 1 – The volume of water allocated for irrigation has been assumed to be at an assurance of supply of 80%.

Streamflow reduction due to afforestation is estimated at 31 million m^3/annum. This was taken into account when determining the available yield from dams and was not included as a water requirement in **Table G3.**

- **Future**

While there is a demand for additional irrigation, it is highly unlikely that new licences will be granted for irrigation due to the stressed nature of the catchment. The irrigation requirements are therefore assumed to remain constant for future years.

There has been rapid growth in water use in the domestic/industrial sector especially in the metropolitan area of Emalahleni (formerly Witbank) and Middelburg, while the growth in water use in rural areas has been limited by the lack of water supply infrastructure.

The mining sector grew very rapidly in the Middle Olifants due to the surge in the platinum price and this prompted the construction of the De Hoop Dam. However, the economic downturn in 2008 has put many new planned mining developments on hold. The rate of development and extent of future water requirements of the mining sector, are now uncertain. The most likely growth remains in the Middle Olifants, with very limited expansion of mining water demands in the remainder of the catchment.

Although one or more additional power stations are planned for the catchment, the water transfers from the Upper Komati and Vaal Systems will be increased to meet the demands of these new power stations and the water balance of the Olifants River system itself will not be affected by these developments.

Streamflow reduction due to afforestation will not increase as new licences for forestry will not be issued in the Olifants River catchment. The on-going removal of Invasive Alien Plants (IAPs) in the catchment should result in an increase in streamflow.

WATER QUALITY

Water quality is determined by the activities in the catchment, the land use and the geology. Water quality guidelines published by the Department were used to develop a combined guideline for the study area based on Domestic, Agriculture and Aquatic Ecosystem water guidelines.

There are a number of water quality concerns in the catchment, for the most part immediately downstream of point sources of pollution. This is often due to lack of treatment or poor management of treatment works, so that the required effluent standards are not being met. However, the quality of water in the catchment is generally suitable for most users, although there are some exceptions.

The Middelburg Dam (station B1H004) is under pressure as reflected by the pH, levels of ammonia as well as nitrite/nitrate levels. The low pH levels can be ascribed to acid mine water as a result of mining activities in the study area. The high levels of ammonia and nitrate/nitrite are primarily a consequence of the use of fertilisers, and a result of poor sewage treatment. The phosphates are slightly high throughout the study area, but still within the acceptable range. This is probably due to improper use of fertilisers, as well as discharge of untreated or partially treated sewage into water sources. Although the chlorides are generally within the ideal range, trend analysis shows that they are on an upward trend. This is probably due to an increased discharge of treated waste water.

The Electrical Conductivity (E.Cond) values are also slightly high, but still within acceptable and tolerable ranges. The trend analysis also shows E.Cond as being in an upward trend for most of the stations. This can be attributed to the various mining activities in the study area.

Most of the dams in the Olifants River System are oligotrophic, except for the Bronkhorstspruit Dam, which is in a hypertrophic state. However, nutrient levels, especially phosphorus, show an upward trend. This can be ascribed to the substantial sewage treatment plant return flow volumes in the Klipspruit, Witbank and Middelburg Dams to Loskop Dam catchments. The return flows contribute to the base flow into Loskop Dam and have been cited as a cause of eutrophication in the upper reaches of the Loskop Dam and the Klein Olifants River (DWA, 2004).

The quality of the water is currently deteriorating and this trend will continue if appropriate management actions are not taken. It is necessary, for example, to substantially reduce or eliminate the discharge of poorly treated waste water from urban areas, and employ best practice in the agricultural sector. Less visible problems associated with substances such as trace metals must be dealt with at source and represent a pollution problem, and not a water resource management problem. The exception to this is the recovery and treatment of acid mine drainage in the upper part of the catchment. The water in the mined areas represent a source of water, while on the other hand, if the decanting water is not treated (desalinated), the water in the Loskop Dam will be compromised in terms of the sulphate concentrations. This will mostly affect the fitness for use for power generation.

THE WATER BALANCE

The current (2010) water balance prior to the commissioning of De Hoop Dam is presented in **Table G4.** It is assumed here that the minimum low flows agreed to enter the Kruger National Park are the only assured flows released for the environment.

Table G4: Water Balance with minimum Ecological flows into the KNP (Units: million m3/a)

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	612		6
Middle Olifants	128	156		(28)
Lower Olifants	202	218	18	(34)
Total	**948**	**986**	**18**	**(56)**

Note: Excludes De Hoop Dam

Table G5 indicates the future water balances for 2030, including the full Ecological Reserve water requirements (EWR).

The EWRs have been based on the 1999 Ecological Reserve study, completed in 2002 [DWAF, 2002].

Table G5: Future (2030) Water Balance (Units: million m^3/a) based on a High Growth Scenario

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	648	80	(110)
Middle Olifants	227	214	51	(38)
Lower Olifants	202	230	69	(97)
Total	**1047**	**1092**	**200**	**(245)**

Note: Includes De Hoop Dam

Both the current and future water balances show deficits for the system as a whole. The Middle Olifants will have a slight surplus once the commissioning of the De Hoop Dam is complete (prior to the phasing in of the Reserve), but by 2030 all Management Zones will have a water deficit if the EWR is supplied throughout the catchment.

The water requirements therefore exceed the availability and the catchment is, by definition, “stressed”.

TOWARDS ACHIEVING A WATER BALANCE

- International Conventions and Requirements

  After the Reserve, comprising Basic Human Needs and the environmental requirements, international obligations are afforded the second highest priority in the National Water Act (NWA). The international agreement between South Africa and Mozambique for Massinger Dam does not specify a minimum flow quantity or quality, but South Africa is party to international policies and protocol and the flow across the border must be reasonable (both in terms of quantity and quality).

- Water Quantity

  The water requirements within the study area already exceed the available resource. This situation must be resolved through a combination of reducing the water requirements and increasing the available resource.

- Objectives and Assumptions for Water Reconciliation in the Catchment

  Reflecting on the status of the water resources of the basin, described above, it is necessary to agree to objectives for the management assumptions on the future use of the resource.

  The water reconciliation objectives are to:

  - Recognise South Africa's International Obligations in terms of sharing the water resource between South Africa and Mozambique.
  - Balance the social and economic water requirements and the protection of the environment to achieve sustainable development.
  - Ensure that water is used efficiently
  - To eliminate all unlawful water use

The initial assumptions on future water use are:

Assumption 1: Water for basic human needs in the study area will be made available. Together with this, appropriate sanitation must be provided.

Assumption 2: The Environmental Water Requirements (EWR) will be met as soon as practicable.

Assumption 3: Water for strategic use for the benefit of the country (e.g. water supply to power stations) will receive priority above any other economic development.

Assumption 4: Water for economic growth in the study area, within the policy parameters of the government, will as far as possible be provided.

Assumption 5: There will be no further expansion in the total irrigation area.

POSSIBLE INTERVENTION OPTIONS

It is important to note that the water shortages experienced by diffuse irrigators will not be addressed by this reconciliation strategy.

A list of all identified reconciliation options was compiled and screened at a Preliminary Screening Workshop held on 7 July 2010. The following reconciliation options were retained after the screening and are currently being investigated.

- Options that will Reduce Water Requirements
  - Eliminating Unlawful Water Use: Eliminating unlawful use is a reconciliation option that must be tackled by the Department as a matter of urgency. The volume of water that can be freed up can only be ascertained once the validation and verification studies have been completed by the DWA. For the purpose of this preliminary reconciliation strategy, it was assumed that at least 5% of the current irrigation water use can be recovered.

Water Conservation and Demand Management: Implementation of Water Conservation and Demand Management (WCDM) can rapidly and significantly reduce water use and alleviate some of the pressure on the available supply.

Reducing Assurances of Supply: Further water allocations may be possible if existing water users agree to accept lower assurances of supply. Possible incentives could be lowering water charges in times of water shortages, or compensating for losses as a result of increased water shortages.

Compulsory Licensing: The NWA allows the Minister to require all water use to be licensed. The procedure requires nearly all existing users to apply for a licence. The Minister considers all the licence applications taking cognisance of the water availability and may license or where required reduce the existing uses to ensure that the Reserve (EWR plus BHN) is met and there is a water balance. The Minister may also reallocate the available water in fair and equitable manner.

Compulsory Levy and Purchasing Water Entitlements: The full Compulsory Licensing process could be long and tedious. An alternative approach to reduce water use would be for the Minister to levy an additional water use charge on all users of water originating in the Olifants River Catchment in terms of Section 57 of the NWA. This levy would have to be in accordance with the pricing strategy which provides for, inter alia, setting water use charges for achieving the equitable and efficient allocation of water (Section 56 (c) of the NWA). The financial contributions of all the water users would be ring-fenced and used to buy out water entitlements from those water users who are willing to sell. This process can then be continued until the necessary water balance is achieved.

- Options that will Increase Water Supply
  - **Groundwater Management and Development:** It is estimated that 25% of the aquifers in the Olifants River Catchment are over-utilised. It is also estimated that up to 70 million m^3/annum of additional groundwater resource could be the developed in the quaternary catchments that are not stressed. This is especially true for the

dolomite aquifers in the northern escarpment areas where there is potential for the future development of regional groundwater resources. However, this will require very careful investigation and management.

- **Utilising the Acid Mine Drainage in the Upper Olifants:** The possibility for reclaiming acid mine drainage water from coal mines and using underground water stored in the mine shafts exists in the upper part of the catchment. This water must be treated - with desalination using reverse osmosis a major part of the process.

- **System Operating Rules:** The dams within the Olifants River are currently all operated independently, without due consideration of the state of storage of other dams, or of the system as an integrated system. It is probable that operating rules which consider the conjunctive use of all resources within a systems context, and detailed information on the timing and location of water requirements (similar to the systems used in the Orange, Komati and Crocodile (East)) River basins, would improve the efficiency of use of the available resource.

- **Rainwater Harvesting:** Rainwater harvesting provides immediate access to water by homesteads and small community facilities such as schools or clinics for domestic purposes and for subsistence vegetable growing. It is particularly useful for those not located near to reticulation networks.

- **Rainfall Enhancement:** Cloud seeding was found to benefit the yield of farm dams but not the runoff to the Vaal catchment when practiced in the Bethlehem area of the southern Free State. The programme has since been moved to the escarpment areas of the Eastern Cape, where some measure of success was experienced in increasing the rainfall over commercial tree plantations. [Eales, et. al, 1996].

Such a programme could possibly be replicated for the Olifants catchment. The possible benefits and costs would need to be properly investigated. This would require a pilot project.

- Importing Treated Effluent from the East Rand: It is possible to pump treated effluent from the Vaal River System, over the catchment divide, into a tributary of the upper Olifants River. For this assessment the seven most suitable works were selected. 38 Million m^3 per year can be added via this configuration.

- **Importing of Water from Vaal Dam:** DWA recently commissioned the VRESAP scheme to pump 160 million m^3/annum of raw water from the Vaal Dam into the Vaal-Olifants watershed. This water is fully committed to Sasol at Secunda in the Vaal Catchment, and Eskom in the Upper Olifants Catchment. This scheme comprises a 1 900 mm diameter pipe over 110 km to Knoppiesfontein on the watershed, from where it gravitates down a 20 km long pipe to discharge into the Trichardtspruit, a tributary of the Olifants River.

This scheme could be duplicated to transfer another 160 million m^3/annum into the Upper Olifants River. The cost and availability of Vaal River water are major considerations.

- **Water Transfer from the Crocodile (West) System:** A possible water transfer from the Crocodile (West) & Marico System, which has only recently become an option as a result of the lower water demand from the Crocodile than originally estimated, has not been investigated, but it will be considered in the run-up for the final Reconciliation Strategy.

- **Raising of Blyderivierspoort Dam:** The existing storage capacity is 55 million m^3/annum, which is only 20% of current day MAR. Whilst there is enough water, a site visit showed that the height of the existing dam is ideal for its situation, and that raising of the dam will pose significant challenges and be relatively expensive.

- **New Dam at Rooipoort:** In 1993 and again in 2001, DWA undertook feasibility studies for a possible dam on the Olifants River at Rooipoort, but found that the dam was not very favourable for a number of reasons:

  - The yield was relatively small because of the many upstream dams;
  - Geotechnical investigations established that the dam had particularly unfavourable foundations;
  - The dam would have flooded two provincial roads which would cost as much to relocate as the cost of the dam wall; and
  - The dam would flood all or part of some 12 villages, requiring relocation of more than 300 households.

In 2007, DWA undertook a study to compare the Rooipoort Dam with the proposed De Hoop dam on the Steelpoort River. It was found that for the same construction cost, the De Hoop Dam yield was twice that of the Rooipoort Dam, and did not have the serious social impacts identified for the Rooipoort Dam. The De Hoop site was therefore selected, and the dam is currently under construction.

It has recently been suggested that a dam at a site approximately 20 km downstream of Rooipoort might be more favourable, with a slightly higher yield, being downstream of the Mohlapitse tributary, and with less social impacts than the Rooipoort site, but this has not been studied at this time.

- **New Dams in the Olifants River Gorge:** Two potential dam sites have been identified downstream of the Steelpoort tributary, namely:

  i) Godwinton; and
  ii) Chedle.

Both sites are located on dolomite. The typical cavernous nature of dolomites means that the foundations for both dam sites must be proven by more detailed geotechnical investigations than usual. Equally important is the possibility of both dams draining out and into the dolomites through the dam basins. Detailed investigations will be required of water table levels around the dam basin to determine whether water will drain out of the dams, to what extent, and whether this would be recoverable.

Another opportunity, as yet quite unexplored, is that the dolomitic geology in the vicinity of the Godwinton and Chedle sites could allow for the underground storage of Olifants River water by directing this into dolomitic caverns as artificial recharge. Such option has not as yet been investigated and could be considered when investigating the two dam sites in greater detail.

– **New Dams in the Lower Olifants River:** To maximise the yield from the Olifants River, it would be necessary to capture the flow from all the major tributaries. The reach immediately downstream of the Blyde River confluence has therefore been examined and three possible dam sites have been identified, namely:
  i) Epsom;
  ii) Mica; and
  iii) Madrid.

A dam at any of these sites will be very expensive compared with dams in the Gorge and are too low down in the catchment to supply users other than the Kruger National Park.

– **Removal of Invasive Alien Plants:** The current infestation of 1 917 km^2 is estimated to use 31 million m^3/annum more water than the indigenous vegetation which these invasives have replaced. It is estimated that, with an intensive clearing programme, 15 million m^3/annum could be added back into the system over the next 8 years, with more to follow. Actual impacts on yield require additional assessment.

BALANCING THE WATER REQUIREMENTS WITH THE WATER RESOURCE

The management reconciliation options can generally be implemented sooner than the development reconciliation options and require less capital.

Table G6 shows the management options that can make a significant difference in the water requirements or water availability along with the estimated savings/supply increases.

Table G6: Management Options

Option	Starting Year	Duration (Years)	% Saving Supply increase	Estimated Saving / Yield million m^3/a	Comments
WCDM Irrigation	2011	5	10%	28	Includes both leakage controls through refurbishment of canals and beyond field edge water savings. Only scheduled irrigation was considered. Should be linked to compulsory licensing.
WCDM Urban	2011	5	15%	25	15% saving is attainable. Emalahleni has

Option	Starting Year	Duration (Years)	% Saving Supply increase	Estimated Saving / Yield million m^3/a	Comments
					already developed a WCDM, strategy and the other towns should follow. Could start immediately.
WCDM Mining	2011	5	10%	8	Includes possibilities of water reuse and recycling. Should be linked to compulsory licensing.
Compulsory Licensing Irrigation	2015	4	See WCDM (10%)	See WCDM (28)	Dependent on validation and verification process (± 4 years) which must first be completed. Linked to WCDM.
Operating Rules	2011	2	5%	47	Requires minimum capital cost inputs.
Unlawful Water Use	2015	4	5%	25	Dependent on validation and verification process (± 4 years) which must first be completed.
Removal of IAPs	2011	8		15	Half of the estimated water use of 31 million m^3/a.
			Total saving / yield	**133**	

Three possible reconciliation scenarios have been analysed, i.e.:

- **Scenario 1:** Comprising the implementation of:
  - The management options as per Table G6, plus
  - The full Reserve (that will reduce the available water by 200 million m^3/a at 98% of assurance), phased in over 8 years, plus
  - The groundwater development options phased in over 16 years, plus
  - De Hoop Dam commissioning in 2012; and
  - Godwinton Dam commissioning 2022.

- **Scenario 2:** Same as Scenario 1, but instead of the Godwinton Dam in 2022, the Vaal Transfer Scheme is also introduced in 2022.

- **Scenario 3:** Comprising the implementation of:
  - The management options as per Table G6 plus
  - Half the effect of the implementation of the Reserve (this will reduce the available water by 100 million m^3/annum at 98% of assurance), phased in over 8 years, plus
  - The groundwater development options phased in over 16 years; and
  - No further dam or transfer option after De Hoop Dam.

The results were as follows:

- Water balances could be achieved for all three scenarios up to 2035.

- There is little difference between Scenario 1 and Scenario 2. The size of the Vaal Transfer Scheme can be halved to 80 million m³/annum.

- The Reserve plays a major role as can be seen with Scenario 3. For half the Reserve requirement, a water balance can be achieved. This is illustrated in Figure G2

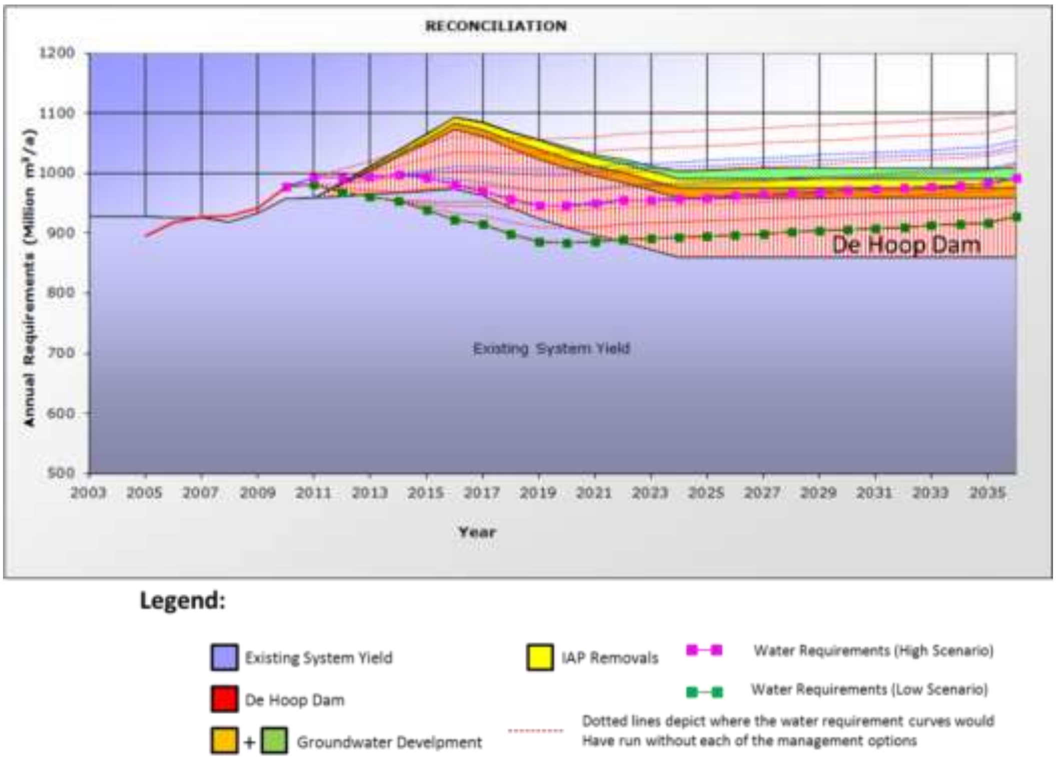


Figure G2: Water Balance – Scenario 3

RISK AND UNCERTAINTIES

The following risks and uncertainties have been identified:

- The requirements of the environmental Reserve are a major demand on the system, but whether the signed off requirements have been set too conservatively is still a question. A very small deviation here involves huge volumes of water. It is critically important that the needs of the Reserve should be re-assessed and correctly and accurately estimated.

- The extent of unlawful water use is a big unknown. Until the validation and verification processes are complete, the strategy will have to rely on the best estimates.

- The estimates for water savings on irrigation water could be inaccurate and attention is needed to improve the estimates. Since the irrigation sector represents such a large portion of the total water use, further work on this aspect is justified.

- The additional yield which becomes available as a result of additional infiltration on the surfaces of existing and decommissioned coal mines, as well as the storage volume created by the mine shafts and galleries is unknown. This aspect needs more attention.

- The Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) needs to be verified. The survey looks as if it could be an over-estimation of IAPs, but if correct, it will affect the water balance negatively. There are various methodologies for determining the streamflow reduction as a result of IAPs. Consensus needs to be reached within DWA on the methodology to be used in future. This study's methodology may differ from the one that will be adopted by DWA.

- The assumption that the water supply from farm dams and run-of-river uses is equal to the available water for these uses could have some inaccuracies. Neither an accurate usage per unit area nor the assurance of supply to these irrigators can be determined.

- The success of the compulsory levy and the purchasing of water entitlements as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements for sale and how much water will eventually be freed up. As a result of this uncertainty, the compulsory licensing alternative was chosen for the analyses.

- It is not known whether farmers will consider accepting lower assurances of supply. If so, this could be a valuable option to be assessed further.

- Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc.

- The outcome of the Classification process that has now started as a separate study can have a significant impact on the setting of the resource quality objectives and therefore the EWRs.

- If any one of the investigated dam options needs to be factored in, the dolomite dam basins and foundation of the Godwinton and Chedle sites need to be investigated further.

RECOMMENDATIONS

The following is recommended:

- The uncertainties listed above need to be investigated further in order to base the Final Strategy on improved information.

- A thorough investigation into the Reserve is recommended, as a lesser effect of the implementation of the Reserve could render a further large augmentation option after De Hoop Dam unnecessary (See Scenario 3).

- All the possible management options to reduce water requirements should be implemented as soon as possible.

- The WCDM for irrigation and mining should be linked to compulsory licensing or the compulsory levy for purchasing water entitlements. In the case of compulsory licensing, the validation and verification process needs to be complete.

- The option of implementing a compulsory levy to fund the purchase of water from willing sellers could also be explored. Compulsory licensing must, however be initiated. Should a compulsory levy be accepted and implemented, this would reduce the impact of compulsory licensing.

- The validation and verification process should be accelerated. Both the compulsory licensing and the completion of eliminating of unlawful water use are dependent on this task.

- The establishment of a catchment management agency for the Olifants River has to be accelerated.

- Groundwater development in unstressed sub-catchments must be encouraged. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River.

- Bulk water abstraction from the Malmani aquifer where it crossed the Olifants River must be investigated together with the possibility of artificial recharge with surface water.

- An indicative conclusion at this point in time is that either the Godwinton or Chedle dam sites would provide the most economical development option; these are well located in relation to the mining developments in the Middle Olifants River. Further investigations into these dam sites are recommended.

- The two water transfer options also seem too costly despite the advantage of bringing water to the headwaters of the catchment. A possible water transfer from the Crocodile system, which has only recently become an option as a result of lower water demand from the Crocodile than originally estimated, has not yet been investigated. It is recommended that its investigation is included in the final reconciliation strategy.

- Water trading should be encouraged, with the State providing the market and buying out water to meet the needs of the Reserve. This would provide water at a far lower cost than the construction of an additional dam, or the importation of Vaal River water.

- The impacts of all interventions must be continuously monitored. Given the many uncertainties it is essential to stay ahead, respond rapidly, and to manage the system as indicated by successes or failures in measures applied.

ANNEXURE H:
LIABILITY OF THE RESPONSIBLE AUTHORITY FOR CHANGES IN YIELD ASSESSMENT

The finding of the Legal Assessment can be summarized in the two following basic questions:

Legal Question 1
To what extent is the Department bound to supply water to upstream water users by having used erroneous water use data (based on unlawful water use)?

Summary of Findings – Question 1

- The inclusion of water use data remains a version of what uses are exercised and cannot serve as a condonation of unlawful water uses.
- Water use rights can only be acquired by authorisation under the Act.
- The Responsible Authority (Dept.) can only be bound if water uses have been confirmed by proper verification (process) or by authorisation,
- It is recommended that verification and compulsory licensing of water uses are undertaken as a matter of urgency.

Legal Question 2
What is the liability of the Department for damages suffered by the mining industry in the case of a reduction of mining allocations?

Summary of Findings – Question 2

- The Department can be held liable for guaranteed assurance of supply if it can be proved that the Department failed to effectively control illegal water use which will impact on the catchment yields.
- Permit/License holders not in a favourable position if the Department has taken reasonable steps to comply.
- The Department has powers to reduce or terminate existing lawful water uses. However, if the reduction aims to mend the effect of uncontrolled illegal upstream uses, compensation might be necessary.
- It is recommended that the control of illegal abstraction in the catchment receives urgent attention